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TABLE OF CONTENTS

Blister rust relations of cultivated species of red currants. GLENN GARDNER HAHN 341

Observations on Cercospora leaf spot of tobacco and the question of varietal resistance ..... RUTH A. MCLEAN 354

Some relationships between potato yellow-dwarf virus and the clover leaf hopper ..... L. M. BLACK 363

An Alternaria disease of zinnia ..... A. W. DIMOCK AND JOHN H. OSBORN 372

A description of the fungus causing cotton rust and a preliminary survey of its hosts ..... JOHN T. PRESLEY AND C. J. KING 382

Diplodia blight in coniferous seedbeds. CHARLES M. SLAGG AND ERNEST WRIGHT 390

Convex gum, a new disease of citrus in China ..... LIN KUNG-HSIANG 394

The effect of soil and chemical mixtures on the growth of Fusarium oxysporum cubense ..... CLIFFORD H. MEREDITH 398

The composition of white clover leaves as affected by rust and by sulphur ..... J. T. SULLIVAN AND S. J. P. CHILTON 401

Phytopathological Notes 403

- The antagonism of Actinomyces to Fusarium oxysporum cubense ..... CLIFFORD H. MEREDITH
- Resistance of the genus Nicotiana to Phytophthora parasitica Dastur var. nicotianae Tucker ..... H. H. FOSTER
- Leaf spot on Terminalia arjuna ..... ANNA E. JENKINS
- A differential medium for the isolation of Phytomonas sepedonica ..... E. A. MARTEN, C. V. LOWTHER AND J. G. LEACH
- Leaf blight of corn ..... C. W. ELLETT
- Influence of plant populations upon incidence of pineapple yellow spot ..... M. B. LINFORD
- Thiosan (tetramethyl thiuramdisulfide) and scurf control of sweet potatoes ..... ROBERT H. DAINES

Report of the Annual Meeting of the Council of The American Phytopathological Society for the Year 1942 413

BLISTER RUST RELATIONS OF CULTIVATED SPECIES OF RED CURRANTS

GLENN GARDNER HAHN

(Accepted for publication September 8, 1942)

INTRODUCTION

In 1922, when Spaulding (12) reported blister-rust-inoculation studies of a considerable number of red and white garden currants, performed by himself and associates, there were practically no data in the literature dealing with this phase of research on *Cronartium ribicola* Fisch. These ribes were grouped by him (12, Table 1) for convenience under the name *Ribes sativum* (Rchb.) Syme (*R. vulgare* Lam.), as it was impossible at that time to assign them to the proper species to which they individually belonged. Shortly thereafter Thayer (13) published the results of taxonomical and field studies of the red and white currants. He found that they were of mixed parentage, but concluded that certain varieties sprang from each of the following species: *R. petraeum* Wulf., *R. rubrum* L., *R. sativum*, and *R. sativum* var. *macrocarpum* Bailey.

Before entering into a discussion of the known facts concerning the pathological relationships of the different groupings of the cultivated species of red currants according to the Thayer (13) classification, and an estimation of pathological data as they relate to white-pine infection studies, the results of recent greenhouse investigations of Red Dutch (Holländische Rote) are presented. This commercial variety of continental Europe, which has been in cultivation many years, is compared morphologically with another variety of similar origin, the commercial variety Viking (syn. Rød Hollandsk Druerips) from Norway. Viking is the only resistant type of red currant variety reported in blister-rust literature that has been investigated intensively (1, 4, 6, 7, 8).

In this paper the anglicised name "Red Dutch" is used for the continental European variety Holländische Rote (syn. Rouge de Holland). As Thayer (13) has pointed out the terms "Dutch" and "Holland" are unfortunately not synonymous, and the "Red Dutch" of the continent is different from the "Red Dutch" of England and the "Red Dutch" of the United States. The varieties from England and the United States belong to *rubrum* and *sativum*, respectively, whereas the continental variety shows predominant *petraeum* characteristics.

RED DUTCH (HOLLÄNDISCHE ROTE)

Pathological History

At the time the writer was performing greenhouse inoculation tests with the blister-rust-immune Viking at the Royal Botanic Garden, Edinburgh, Scotland (4), and in the United States (6), the late, eminent forest pathologist, Professor von Tubeuf, assisted by Wolpert (15, p. 436), was conduct-

ing, independently, field inoculation tests with another rust-immune garden variety, Red Dutch (Holländische Rote), at Munich, Germany. The last-named variety has been the subject of pathological investigations by other European scientists, who reported it as being highly resistant to *Cronartium ribicola*. As early as 1903, Red Dutch was recognized by Ewert (3) as being exceedingly resistant to the disease of white pines. Twenty years later Schellenberg (9), in Switzerland, made a similar report as the result of an investigation of the ribes population in his country, studied for the purpose of determining the individual significance of the different species in the spread and intensification of white-pine blister rust. In Switzerland, Red Dutch has been cultivated extensively as a commercial variety, and observations could be made readily in localities where it grew in close proximity to the commonly cultivated and heavily infected European black currant (*Ribes nigrum* L.).

Similarly, in 1917, Tubeuf (14, p. 300) reported, on the basis of field observations, that the variety Red Dutch (Holländische Rote) was not attacked by blister rust. Susceptible ribes in the immediate vicinity of this variety, however, were severely affected by the disease. It was not until 1928 to 1932 that he and Wolpert (15) demonstrated Red Dutch to be immune from blister rust as the result of inoculation tests covering five years. Shortly thereafter Tubeuf (16, 17) advanced recommendations for the control of white-pine blister rust in Germany, wherein he advocated, along with the complete destruction of the damaging European black currant, the cultivation solely of the rust-immune Red Dutch as a substitute for all other horticultural varieties, and its distribution under controlled conditions.

Inoculation Results

In 1937, G. M. Darrow, Division of Fruit and Vegetable Crops and Diseases, Bureau of Plant Industry, became interested in the rust-immune red currant reported by Tubeuf as the result of information given to him by the writer. The following year at Darrow's suggestion, cuttings of the variety were obtained from the Grafrath Experiment Station, Munich, by the Division of Plant Exploration and Introduction (P.I. No. 127062) for study in this country. It is not known whether this stock originated from the same clone as that investigated by Tubeuf (15). We are probably correct, however, in assuming that the introduced Red Dutch stock represented the variety as it is distributed through trade channels on the continent.

After the receipt of the import stock, part of the shipment was retained at Beltsville and Glenn Dale, Maryland, for propagation, and 50 cuttings were sent at a later date to the writer at New Haven. Unforunately the cuttings arrived in poor condition and the writer succeeded in obtaining only two plants from the entire lot. The number of experimental plants at New Haven was augmented later by four additional plants obtained in 1941 through the courtesy of W. E. Whitehouse, Division of Plant Exploration and Introduction, Bureau of Plant Industry.

On Red Dutch. On June 5, 1939, 2 potted plants of Red Dutch, growing vigorously in the greenhouse, and with leaves showing all stages of development from those unfolding at the growing tip to those fully mature, were tested with freshly collected aeciospore inoculum[1] of *Cronartium ribicola* collected in Maine. A total of 31 leaves were inoculated and, approximately 2 weeks later, the same leaves on these 2 plants were reinoculated with aeciospore inoculum collected in Connecticut. In these tests the European variety proved immune.[2] The following year, on June 21, the same Red Dutch plants were retested with aeciospore inoculum collected in Maine. A total of 55 leaves were inoculated and the same results were obtained as in 1939.

On June 2, 1941, the experiments on the same two Red Dutch plants were repeated with Connecticut aeciospore inoculum. A total of 80 leaves were tested and these plants for the third season proved to be immune. At the same time 30 leaves on 2 of the Red Dutch plants received from Glenn Dale also were tested, with similar results. Later, on June 19, the two remaining plants (29 leaves) from Glenn Dale were tested with urediospore inoculum produced on heavily infected European black currants growing in the greenhouse. Red Dutch proved to be immune also from urediospore infection.

In the above experiments, it was observed that mature leaves of Red Dutch inoculated with *Cronartium ribicola* were unaffected. However, tender leaves that had just become fully expanded or were in the process of becoming so showed the presence of necrotic flecks. Similar flecking has been described and illustrated by the writer (4, Pls. 13, 14) on young leaves of Viking inoculated with blister-rust spores. Anderson (1) demonstrated cytologically that in Viking, these necrotic flecks were the result of the invasion of the new leaves by the blister-rust-spore germ tubes, which extended into the substomatal cavities for a brief distance, only to degenerate and die shortly after penetration. He also showed how the death of the invading germ tubes was associated with the death of host cells in their immediate proximity. Although a similar cytological study of probable germ-tube penetration has not been made in the case of Red Dutch (Holländische Rote), it is reasonable to expect that what occurs in the case of Viking also takes place in the case of Red Dutch. Red Dutch has been under observa-

[1] The writer desires to express his appreciation to Messrs. J. M. White, J. E. Riley, Jr., and Alton Miller, Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, for their cooperation in the collection of blister-rust aeciospore inocula used in the experiments outlined in this paper.

[2] The term "immune" has been applied to the Viking currant in previous publications (4, 6, 7, 8). As the writer indicated previously, the Norwegian variety at certain stages of leaf development is not free from the invasion of germ tubes of *Cronartium ribicola.* However, Anderson (1) has demonstrated clearly by cytological studies, which have corroborated extensive observations made by European pathologists and the writer, that *the infectious agent is unable to establish itself in Viking, i.e.,* there occurs the prompt death of both the invading pathogen and the host tissue itself at the point of attack. Such a condition may be described as "abortogenic necrosis," to use a term submitted at a meeting of The American Phytopathological Society (18). On this basis the writer has reserved the term "immune" for the case of Viking and other red currant varieties showing a similar response to an invasion by *C. ribicola.*

tion by European pathologists *for many years* and fructifications of blister rust on leaves of this common European variety have never been reported.

In every experiment *Cronartium ribicola,* inoculated on known-susceptible ribes used as "checks" to establish the viability of the inoculum and suitability of the environmental conditions, produced abundant fruiting bodies. During all of the tests urediospores of blister rust formed on these and other susceptible ribes, including heavily infected European black currants, were being disseminated naturally during the summer and autumn in the greenhouse in which the tests were carried out. Although the Red Dutch plants under investigation were exposed constantly to urediospore inoculum, they maintained their immunity from natural infection.

On Viking Selfed-seedling "Escapes." The experiments described above included tests performed simultaneously with two naturally pollinated, second-generation seedlings of the rust-immune Viking (8). These plants undoubtedly originated as the result of self-pollination for there were no other red currant varieties growing nearby, and there is no evidence that pollen of currants is carried any appreciable distances. Accordingly they could be regarded as Viking selfed-seedling "escapes," since they appeared spontaneously in a small field planting of the red currant from Norway maintained for horticultural testing. These two escapes showed the morphological characteristics of the Viking parent.

In 1939, 24 leaves of the Viking escapes in all stages of leaf development were tested with Maine aeciospore inoculum, and later, reinoculated with Connecticut aeciospores. In both tests the selfed seedlings proved immune. Similar results were obtained on the same plants in 1940 and 1941, when 67 leaves were tested, 25 with Maine aeciospore inoculum and 42 with Connecticut aeciospore inoculum. As in the case of the Red Dutch experiments, although the Viking escapes were exposed constantly to free urediospores of *Cronartium ribicola* produced abundantly in the greenhouse on European black currants, they continued immune from the pine disease.

Comparison with Viking

Tubeuf (15, p. 439) classified Red Dutch (Holländische Rote) as the hybrid species, "*Ribes houghtonianum* Jancz. (= *R. rubrum* × *R. sativum* or *R. pallidum* Otto and Dietrich)." In a footnote (15, p. 460), however, he called attention to the taxonomic opinion of the well-known American horticulturist, Alwin Berger (2), who regarded "Holländische Rote, Rouge de Hollande, German Sour, Verrières rouge, etc." as synonyms of the hybrid species, "*R. pallidum* (= *R. petraeum* × *R. rubrum*)." It is here of interest to point out that both Thayer and Berger recognized Red Dutch as having originated as a *petraeum* hybrid.

The name Red Dutch, which, according to Thayer (13), is one of the oldest garden currants known, first appeared in print in 1670 or 1690. According to the opinion of European horticulturists it originated in part from the high mountain species, *Ribes petraeum, i.e.*, Ewert (3) quotes Maurer of

Jena who was of this opinion. The rust-resistant Red Dutch reported by Schellenberg (9) was undoubtedly of the same origin. Concerning the identity of the Red Dutch, grown commonly in Switzerland, the writer received the following information contained in a written communication obtained through the courtesy of Professor Gäumann of Zurich from Dr. K. Kobel, Horticultural Experiment Station, Wädenswil, (translation) "The currant variety 'Holländische Rote' is widely distributed in Swiss nurseries. This doubtless is true also of the German ones. It is the most important of the cultivated varieties of *Ribes petraeum* to be found abundantly in both countries. . . . It is very probable therefore that the 'Holländische Rote' of Tubeuf and Schellenberg's variety of the same name are identical." The writer (6) already has pointed out that Viking, according to an authoritative Norwegian source, originated as a cross between *R. petraeum* × *R. rubrum*. It becomes very evident, therefore, that the rust-immune varieties, studied pathologically and reported by Ewert, Schellenberg, Tubeuf, and the writer, respectively, were all derived in part from *R. petraeum*, and are closely related.

A comparative morphological study made by the writer (8) of Viking and the hybrid species, *Ribes pallidum*, growing in the Ribes Collection maintained at the Arnold Arboretum, Harvard University, and later a similar study made of Viking and vigorous potted plants of Red Dutch growing in the greenhouse, demonstrated that all of these produced foliage on the new shoots, which showed *petraeum* characteristics, *e.g.*, leaves with three prominently pointed lobes, the lateral ones often unequal in size, the right lobe being frequently the larger (6, Pl. 1; 8, Fig. 1). As has been reported for Viking (6), growth was vigorous, and the unequally lobed leaves were longer than broad, dark green, glossy, rugose, and pale and slightly pubescent beneath. New leaves were held stiffly upright in a conspicuous cupped-shape manner by stout petioles tinged with red. Both Ewert (3), describing Red Dutch, and Darrow (6, p. 3), describing Viking, pointed out that these closely related varieties could be differentiated readily from other garden currants.

In a recent publication (8) it was stated that leaves of naturally pollinated second-generation seedlings of Viking, which for all practical purposes could be regarded as selfed (in seed formation, although cross-pollination with susceptible red currants was not excluded absolutely, its occurrence was most unlikely), for the most part resembled those of the Viking parent. Several hundred of these rust-immune seedlings have been grown in the field since 1936 under conditions of favorable cultivation at the Marsh Botanical Garden, Yale University, and at the Connecticut Agricultural Experimental Farm, Mt. Carmel, Connecticut.[3] Mature plants thus derived from Viking seed showed morphological characters of bush, leaves, and flowers that gen-

[3] The writer wishes to express his appreciation to W. L. Slate, Director, and W. R. Singleton, geneticist, Connecticut (State) Agricultural Experiment Station for courtesies extended and for their cooperation in making it possible to carry on field tests with Viking seedlings at the State Experimental Farm.

erally resembled the *petraeum* hybrid whence they came. Some of these, however, produced white fruit and on bushes whose growth characters resembled closely those of bushes producing red fruit. A number of selections of red- and white-berried plants have been made from the two field plantings. There are excellent chances that a testing of selfed seedlings of these second-generation progeny will demonstrate some of them to be homozygous, *i.e.*, breed true for rust immunity.

The same field plot, in which selected rust-immune Viking seedling stock is being tested, also contains plants of Red Dutch. The fruitful (6) Norwegian commercial variety has shown itself to be well suited to the northeastern part of the United States. The writer is of the belief that the Red Dutch from Germany will be found adapted likewise to this part of the country.

DISCUSSION OF RUST RESISTANCE SHOWN BY HYBRID GROUPS OF RED CURRANTS

Ribes petraeum Group

In the foregoing the rust resistance of Red Dutch (Holländische Rote) and Viking (syn. Rød Hollandsk Druerips), two representatives of a small group showing markedly *Ribes petraeum* characters, has been considered. Accumulated pathological data on other members of this group have shown them to be not only very highly rust-resistant but also some of them, as in the case of Red Dutch and Viking, to be immune from the pine disease. These resistant varieties include Prince Albert (syn. Rivers Late Red, Rivers) and Long Bunch Holland (syn. Holland, Franco-German).

According to Thayer (13), both Long Bunch Holland and Prince Albert are resistant not only to disease and insect attack but also to heat and drought in the Prairie States. In that section of the country he stated that the former variety had done very well, and cited another horticulturist, J. L. Budd, who early (1880) reported it as being the only variety then known that preserved health of leaf during dry, hot summers in this country. Budd had observed that when most of the leaves had fallen from other currant varieties, leaves of Long Bunch Holland were still green and unaffected by leaf diseases. The observations of Budd and Thayer (13) in the United States are in agreement with European observations. Tubeuf (14, p. 300; 15, p. 458), in emphasizing the fact that Red Dutch (Holländische Rote) was not attacked by blister rust, also stated that its foliage was free from *Gloeosporium ribis* (Lib.) Mont. and Desm. infection, as well as from insect damage, statements that were in agreement with similar ones made previously by Ewert (3).

The garden currant blister-rust-inoculation experiments reported by Spaulding (12) included a number made on several *Ribes petraeum* hybrids —Prince Albert, Franco-German, Holland, and Rivers. On the first-named variety Spaulding recorded 18 tests, 4 of which succeeded and resulted in a *slight* infection, both in the greenhouse and out-of-doors. On the remaining varieties tested, he failed to obtain fruiting bodies as the result of 21

tests on Franco-German, 5 on Holland, and 4 on Rivers. Infection on leaves of Prince Albert was not qualified by stating the degree of uredium and telium production, so we have no way of knowing the amount of telia actually formed. We do know however that on the most susceptible variety of the *petraeum* group tested, fruiting bodies were exceedingly scant.

In 1930 the writer (5) reported additional experiments on *Ribes petraeum* stock of the varieties Prince Albert, Franco-German, and Holland. The Holland stock was authenticated by and received from Thayer (13) and G. M. Darrow. The writer found, as Spaulding (12) had reported previously, that Prince Albert bore only a scant infection, which produced very few uredia, whereas the other two forms were immune from *Cronartium ribicola*. Recently the writer received a report of blister-rust susceptibility tests being conducted in currant and gooseberry plantations at the Central Experimental Farm, Ottawa, Canada. The Canadians have found both Viking and Franco-German to be immune from *C. ribicola* over a period of 6 years, 1935 to 1940, despite the fact that these varieties were growing near infected European black currants that became heavily infected during certain years.[4]

Currants derived from *Ribes petraeum* are so highly resistant to blister rust that one is tempted to speculate on the exact form from which these commercial varieties originated. According to Thayer (13), who has as his authority the eminent ribes taxonomist, Janczewski, the probable form of *petraeum* to which we are indebted for our disease-resistant varieties of this species was *R. petraeum bullatum* Janez. It is here of great interest to note that among the rust-resistant, second-generation Viking seedlings (8) referred to above, there occurred a small percentage of plants producing leaves that were exceedingly dark green, smaller (as compared with Viking), and pronouncedly bullate. It would be interesting to compare this particular form morphologically with Janczewski's variety.

Despite the fact that *Ribes petraeum* has been reported susceptible to blister rust (12, 15), there undoubtedly are forms of it that we know very little about in this respect, *i.e.*, we do not have any information on the rust susceptibility of *bullatum*, and data on this variety would be extremely valuable. According to Budd, who is cited by Thayer (13), the variety Long Bunch Holland probably originated from northern European *petraeum* stock. In connection with this opinion, it might be worth while to draw attention to recent correspondence (1938–1939) carried on by the writer with Dr. K. Lepik, Phytopathological Experiment Station of the University of Tartu in Esthonia, concerning blister rust infection of *Ribes petraeum*. Lepik replied that the form in his country became only slightly infected. He submitted representative specimens of *Cronartium ribicola* (telia) on leaves of *R. nigrum* and *R. petraeum;* the former showed 100-per cent infection, whereas the latter showed approximately 5 per cent of

[4] Statements concerning blister-rust-horticultural investigations at the Central Experimental Farm, Ottawa, were communicated through the courtesy of that Station and Mr. D. S. Blair, Assistant in Pomology.

the total surface of mature leaves with telia at the time of collection at the end of August, and the fruiting bodies occurred mostly on necrotic leaf tissue.

In both Red Dutch (Holländische Rote) and Viking, the factor for rust resistance is undoubtedly dominant, but we do not know whether the former is homozygous for resistance. We do know, however, that Viking (8) is nearly so, for, considering the very small percentage (3.7 per cent) of susceptibles that appeared among a large population (1835 seedlings) of naturally pollinated Viking seedlings studied, the indications are that probably only a very small percentage of them are heterozygous, whereas the majority must be homozygous.

Since 1937 the writer has continued to carry on the greenhouse investigation of the susceptibility of the few nonimmune Viking seedlings, appearing in the tests referred to above, in order to determine the degree of telium production on them. Over a period of 4 years these suscepts have been carefully inoculated each year with aeciospore inoculum and have been exposed naturally to urediospore inoculum produced on heavily infected European black currants growing in the greenhouse in which the tests were carried out. As a preliminary report on the tests, it can be stated that infection was meagre, *e.g.*, on the *most susceptible* suscept only a very few telia formed, and after their formation these were observed to occur on tissue that became necrotic.

Ribes rubrum Group

A second group according to the Thayer classification (13, p. 364) shows predominantly the morphological characters of *Ribes rubrum*. This group of varieties, as in the case of the *petraeum* group, is a small one, and is characterized by plants starting new growth late in the spring and holding their foliage late in the autumn. Varieties belonging to the *rubrum* group show considerable variation. They include the variety Victoria which may be regarded as typical of the group, the under side of the leaves being markedly pubescent.

Forms of *Ribes rubrum* that have been investigated (5, 12) produced scanty blister-rust infection or were highly resistant. The varieties studied included Victoria, Raby Castle, Gloire des Sablons, Dilnot Red, Scotch, and London Market (syn. London, London Red, Short Bunched Red), the last-named being very popular in some currant-growing sections—notably, southern Michigan (13).

Spaulding (12, Table 1) reported inoculation tests on at least 12 *rubrum* varieties. On all of these only a *slight* infection was recorded. The variety London was investigated more thoroughly than the others. Twenty-two tests were made; these indicated the variety to be highly resistant (nearly immune). Tests on *rubrum* forms were not qualified by stating the degree of telium production.

At a later date the writer (5) made greenhouse studies of 4 *rubrum* varieties (Victoria, Raby Castle, Scotch, London Market) recorded by Spaulding (12). The stock of Victoria and London Market was authenticated and received from Thayer (13). The writer likewise found that a slight production of fruiting bodies (uredia) occurred under optimum conditions for infection. Rust fruiting bodies did not form on Victoria and there is the possibility that this particular form may have been immune from blister rust.

At the Central Experimental Farm, Ottawa, the variety London Red, has been grown for 6 years, 1935 to 1940, in the blister-rust-test plots alluded to above. Only slight blister-rust infection was observed, although generally speaking the infection on nearby European black currants was considerable or very heavy during this period. London Red was free from infection in 1935, 1938, and 1939. As in the case of results reported by Spaulding (12), those from Canada were not qualified by stating the degree of telium production, which, from the standpoint of pine infection, is the most important stage.

Although *Ribes rubrum* has been reported susceptible to blister rust (12, 15), there are indications of rust resistance among its forms, *e.g.*, Tubeuf (15) cited the variety *glabellum* Trautv. and Mey. as immune from blister rust after 5 years' field testing. This form from northwestern Europe is late in blooming and also holds its foliage late. Spaulding (12, p. 52) too reported resistant varieties and described infections on "*R. rubrum* vars. *petrowalskyanum*, *pubescens*, and *siberica:* very scant sori, located beside large veins of leaf." Inasmuch as the habitat of the species includes a geographical range extending in northern Europe from Scotland, Scandinavia, Poland, and Finland to northern Russia, and from Siberia to eastern Manchuria, it would appear likely that the species would include rust-resistant forms native to the probable original home (Siberia) of white-pine blister rust.

Tubeuf (14, p. 300) rated *Ribes rubrum* growing in the wild state in Germany as producing a reduced degree of infection as compared with that on *R. nigrum* and *R. aureum* Pursh. Schellenberg (9) likewise reported the species growing in Switzerland to be exceedingly resistant to blister rust. Moreover, Spaulding,[5] in unpublished field notes made in Switzerland in August, 1922, while studying blister-rust conditions in Europe, recorded observations on *R. rubrum* made in company with Schellenberg at Zollikon, a few miles from Zurich. In a garden within 150 feet of badly diseased *Pinus strobus* L. planted 30 years earlier, these investigators found both the European black and wild red currants growing in association with other ribes. *R. nigrum* was very heavily infected, whereas only a single infection spot could be found on one leaf of *rubrum*. Spaulding recorded this comment: "The search on *R. rubrum* was careful and thorough as Schellenberg and I were arguing about infection of this species at the time." As

[5] Statement communicated through the courtesy of Dr. Perley Spaulding, Division of Forest Pathology, New Haven, Conn.

in the case of the rust-resistant *petraeum* varieties, it would be extremely valuable to know the exact form or forms of *rubrum* from which rust-resistant varieties of this latter group originated.

Ribes sativum and R. sativum var. macrocarpum Groups

The remaining two red currant groups in Thayer's classification (13, pp. 363–4) in which the characters of *Ribes sativum* and *R. sativum* var. *macrocarpum*, respectively, predominate are large groups. The former included in the early 1920's almost all the varieties recommended for planting in this country. Concerning *R. sativum* (*vulgare*), Thayer (13, p. 317) had the following comment: "This species, which, by the way, has been badly confused in the past with *R. rubrum*, has for its habitat the dense woods, river banks and mountains of France from the Pyrenees to Brittany, Great Britain, Belgium, and possibly other countries of northern and western Europe. The true *rubrum*, on the other hand, is a native of lands much farther north. *R. vulgare* is readily recognized by the blossoms which are uncolored and which show a pentagonal raised ring or pad on the surface of the ovary. . . . *Vulgare* shows but little variation in the wild, and Janczewski gives but one botanical variety, *macrocarpum*. The origin of this variety is shrouded in mystery." The *sativum* group resembles the *macrocarpum* in earliness of leafing, blooming, and ripening, and also in an *early defoliation* (13, p. 373). The American Red Dutch, reported by the writer (6) as being rust-susceptible, according to Thayer (13, p. 373) is probably pure *sativum*.

The *Ribes sativum* groups include those varieties of the cultivated red currants now recognized as most susceptible to blister rust. A large percentage of the varieties reported by Spaulding (12) and the writer (5) belong to these groups and particularly to the *macrocarpum* section. Spaulding (12, Table 1), recording blister-rust infection, unqualified as to degree of uredium and telium production, and the writer (6, Fig. 2), reporting uredium production on varieties belonging to these two groups, indicated, as previously stated by the writer (5, p. 116), that cultivated reds can be considered as only a fair host for *Cronartium ribicola*, for fewer fruiting bodies are produced on them than on most Ribes, even when infected under the most favorable conditions. In estimating degree of infection, the writer compared uredium production on red currants to uredium production under favorable conditions on completely infected leaves of the very destructive European black currant, which was taken as a standard.

In addition, the writer (5, p. 107) commented upon the limited period of receptivity of red currant leaves to blister-rust infection, and Spaulding (12, pp. 52 and 54) described a common necrosis of leaf tissue resulting from infection. His plate V, fig. 4, shows infection on a variety originating from *Ribes sativum* var. *macrocarpum*. As might be expected, this necrosis, together with lesions resulting from other fungus and insect attacks,

very probably augments the natural early defoliation characteristic of the *sativum* and hybrid groups (3; 13, p. 373). In recent publications Snell (10, 11), in connection with very valuable studies of sporidia of *Cronartium ribicola* in relation to infection of white pine, has contributed additional data on necrosis of blister-rust infection spots on red-currant leaves in New York State, and also on defoliation of these plants during the early summer.

Telium production on infected leaves of red currants derived from *Ribes sativum*, has not received all the attention it should, particularly in the Northeast. Additional data are needed not only on the volume of telium and sporidium production on the most susceptible reds including those that have "escaped" to the wild, but also on the viability of telia on *sativum*, especially those on areas of infected leaf tissue which finally die. Further studies also should be made on the season of defoliation of infected red currants in the field and its effect upon white-pine infection.

SUMMARY

Heretofore, in American blister-rust literature, all cultivated red-currant varieties have been lumped for convenience under *Ribes sativum* (Rchb.) Syme (*R. vulgare* Lam.), the most rust-susceptible species of this class of horticultural plants. In the light of our present knowledge of the taxonomical-pathological relationships of certain varieties that belong to other ribes species and that are highly resistant to or immune from *Cronartium ribicola* Fisch., such a treatment must now be considered obsolete.

According to Paul Thayer, whose classification is followed in the present paper, the cultivated reds originated from at least 3 European species—*Ribes petraeum* Wulf., *R. rubrum* L., *R. sativum*, and *R. sativum* var. *macrocarpum* Bailey. Blister-rust relations of cultivated red currants belonging to these groups are discussed.

The *Ribes petraeum* group is small and includes forms whose foliage, blossoms, and fruit appear late, the leaves hanging on the bushes until winter. Varieties belonging to *petraeum* are highly resistant to or immune from blister rust. In the literature the *petraeum* forms, Rivers Late Red, Long Bunch Holland (syn. Holland, Franco-German), Red Dutch (Holländische Rote), and Viking (syn. Rød Hollandsk Druerips), have been reported to be immune and Prince Albert to be highly resistant to blister rust.

Greenhouse inoculation tests on Red Dutch (Holländische Rote), that demonstrated the variety to be immune, are reported in this paper. These results corroborate field tests and observations by the late Professor Tubeuf in Germany.

The morphological characters of Red Dutch (Holländische Rote) and Viking are very similar. During the growing season both immune varieties are distinguishable from the common rust-susceptible garden varieties belonging to *Ribes sativum*.

Although the blister-rust relations of second generation Red Dutch seedlings have not been studied, those of Viking, previously published, showed the latter to breed nearly true for rust immunity. Selections of rust-immune Viking seedlings, some producing red and others white fruit, are reported in this paper. There is the possibility that some of these selections will be homozygous for rust immunity.

A preliminary report is made on telium production on the scant number of suscepts discovered during an earlier study of a large population of second-generation Viking seedlings. Over a period of 4 years (1937 to 1940) meager rust infection was obtained in greenhouse tests, *e.g.*, on leaves of the most susceptible seedling only a very few telia formed and these occurred on areas of leaf tissue that finally died.

The *Ribes rubrum* group likewise is a small one. It includes forms whose leaves are markedly pubescent on the under side. As in the case of the *petraeum* group, the leaves of the *rubrum* group are retained until late in the year. Forms belonging to *rubrum* show a very much reduced degree of infection or are highly resistant. The commercial variety, London Market, has been investigated most extensively and forms of it are reported to be nearly immune.

The *Ribes sativum* and *R. sativum* var. *macrocarpum* groups included in the early 1920's almost all the varieties recommended for planting in this country. The two groups are characterized by earliness of leafing, blooming, and ripening, and by an early defoliation. Most of the varieties that have been tested for blister rust belong to these two groups, which include forms now recognized as being most susceptible for red garden currants. Comparison is made between them and varieties derived from *petraeum* and *rubrum* with regard to their reaction to blister rust. It is pointed out that rust infection, together with lesions resulting from other fungus and insect attacks, very probably augment natural early defoliation of *sativum* varieties.

Despite a considerable amount of published work concerning the blister-rust relations of cultivated species of red currants, there are numerous questions pertaining to varieties belonging to the *Ribes sativum* group that need further investigation, *e.g.*, additional data on the volume of telium and sporidium production, the viability of telia, especially those on dead, infected leaf tissue, and field studies of the season of defoliation and its effect on white-pine infection.

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OBSERVATIONS ON CERCOSPORA LEAF SPOT OF TOBACCO AND THE QUESTION OF VARIETAL RESISTANCE[1]

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(Accepted for publication July 25, 1942)

An outbreak of leaf spot caused by *Cercospora nicotianae* E. and E. on flue-cured tobacco occurred in fields at the Tobacco Experiment Station, Oxford, North Carolina, in 1941. Although this disease is present each year in North Carolina, it is usually of little importance. The early appearance and prevalence of spots in 1941 attracted attention, and, consequently, certain observations were made.

Cercospora leaf spot of tobacco has been reported to cause considerable damage to the crop in Queensland, Rhodesia, Sumatra, Malaya, and Nyasaland (14, 5, 23, 11, 22, 9). In Rhodesia (5) the yearly loss ascribed to it in 1939, was £100,000. The severity of the disease is conditioned by the prevailing weather and, accordingly, varies from year to year in a given location and in different localities.

MATERIALS AND METHODS

The observations involved 2 to 4 rows each of 30 varieties of flue-cured tobacco planted for the production of seeds. About one-third of the plants of each variety had not been topped, and the seed heads had been bagged about 2 weeks before the first observations were made. Counts of all spots on all leaves of 10 plants of each variety were recorded for each leaf according to its position on the stalk. No attempt was made to determine the effect, if any, of topping on the susceptibility of plants to spotting. Identification of the pathogen was attempted by direct microscopic examination and study of cultures.

OBSERVATIONS

Many minute circular to angular necrotic areas, 0.5 mm.–5.0 mm. in diameter, in which hyphae were found, but on which conidia were absent, occurred on all plants under observation. Hopkins (6) of Rhodesia reported similar spots in 1929. Again, in 1933 (7), he reported that Cercospora may produce symptoms almost typical of the brown spot caused by *Alternaria longipes* (E. and E.) Mason. He ascribed the abnormal appearance of lesions to a prolonged, cold, wet period at the beginning of the season followed by a severe drought.

The small lesions observed at the Oxford Experiment Station, when surface-disinfected and cultured, produced sterile mycelium. Potato-dextrose agar, as reported by Nagel (16), was used without success in an effort to secure sporulation. The fungus grew luxuriantly but produced only sterile hyphae on meat-extract agar containing 2 per cent dextrose. It did

[1] A cooperative investigation by the Departments of Botany and Chemistry, Duke University. The writer is indebted to Dr. F. A. Wolf and Dr. P. M. Gross for their assistance in the preparation of this paper.

not fruit on bits of infected tobacco leaf tissue that had been placed in humid chambers for 24–48 hours. Diachun (2) has reported that *Cercospora nicotianae* sporulates readily on tobacco-leaf-decoction agar when cultures are held for 48 hours in the dark at 27° C.

The small necrotic spots, first noted on July 24, increased little in size during the period July 24 to August 20, and the pathogen did not sporulate. The lesions observed would not have been recognized macroscopically during this period on the basis of the classic descriptions of mature Cercospora spots. However, 3 days of favorable weather, commencing August 19 with a rain during the night and continuing through August 22 (Table 1), in-

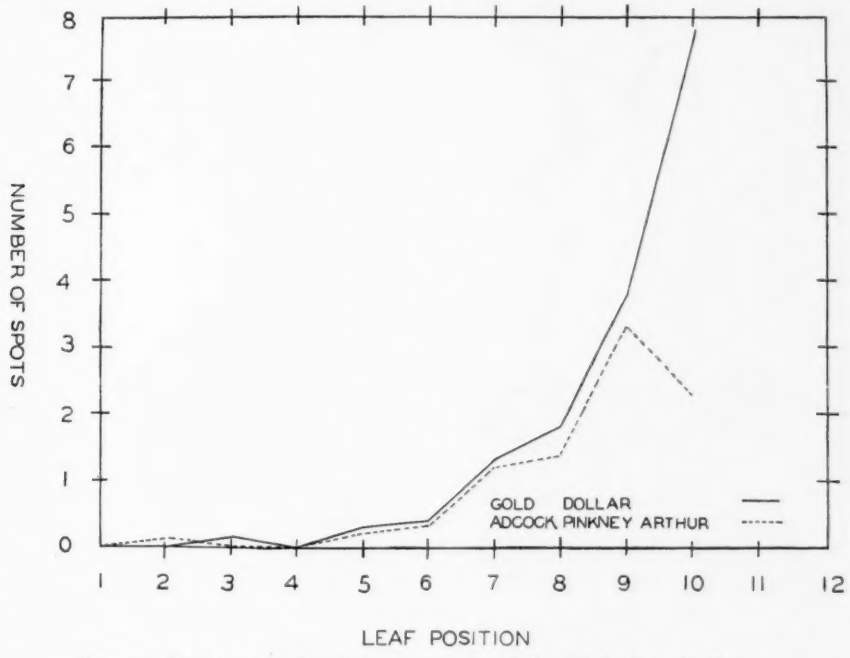

FIG. 1. Spots per leaf position for two varieties of flue-cured tobacco.

duced abundant sporulation on August 22, on more than 50 per cent of the lesions. Weather conditions during these 3 days differed from those of any 3-day period of the interval July 24 to August 19, in the number of hours the atmosphere was saturated, the amount of cloudiness, and in maximum temperatures that were less than 90° F. The interrelation of these factors on the growth and sporulation of *Cercospora nicotianae* is unknown. Mandelson (13) has determined that on culture media in the laboratory 45.5° and 93° F. are minimum and maximum temperatures respectively for growth. It may be assumed that the pathogen in the lesions which did not show sporulation on August 22 did not survive the extremely dry, hot weather of the preceding month.

Abundant sporulation by Cercospora on certain lesions and by Alternaria on others, figure 2, made possible a rapid and accurate differentiation

of spots in the field. The spots counted on July 24 proved, with few exceptions, to have been caused by Cercospora. Three observations, as listed below, are shown by the counts for two varieties, Gold Dollar and Adcock

FIG. 2. Tobacco leaf showing Cercospora spots left of midvein, upper left, and right of midvein, lower left. Cercospora spots are dull gray in contrast to the darker spots with white centers and concentric circles from which pure cultures of *Alternaria longipes* were obtained.

Pinkney Arthur (Fig. 1). The former is representative of varieties showing the highest count at the level of the tenth leaf from the top of the plant and the latter, of those showing the lowest count. Similar counts also were made in other plats on the farm.

1. Several varieties were almost spot-free for the 10th leaf from the top of the plant in contrast with certain other varieties.

2. In the case of all 30 varieties, the upper 5 leaves showed definite spotting but markedly less than the lower leaves.

3. A progressively higher count per leaf, the lower its position on the stalk, was noted in all varieties.

TABLE 1.—*Meteorological data in relation to sporulation of Cercospora nicotianae*

Date	Precipitation[a]	Temperature		Saturation No. hours per 24 hours		Character of day	Sporulation of fungus
		Min.	Max.	Hours	Period		
	In.						
July 24	0.32	61	88	10	8:00 p.m.– 6:00 a.m.	Clear	0
25	0.00	61	92	7	11:00 p.m.– 6:00 a.m.		0
26	0.00	61	93	3	3:00 a.m.– 6:00 a.m.	Clear	0
27	0.00	74	95	8	9:00 p.m.– 5:00 a.m.		0
28	0.00	72	95	3	4:00 a.m.– 7:00 a.m.	Clear	0
29	0.00	73	97	12	8:00 p.m.– 8:00 a.m.	Clear	0
30	0.38	71	95	6	2:00 a.m.– 8:00 a.m.	Clear	0
31	0.15	74	95	12	8:00 p.m.– 8:00 a.m.		0
Aug. 1	0.00	72	96	4	4:00 a.m.– 8:00 a.m.	Clear	0
2	0.00	73	94	4	12:00 p.m.– 2:00 a.m. 4:00 a.m.– 6:00 a.m.	Clear	0
3	0.00	70	92	5	3:00 a.m.– 8:00 a.m.		0
4	0.00	69	91	13	8:00 p.m.– 9:00 a.m.	Clear	0
5	0.73	67	92	6	11:00 p.m.– 8:00 a.m.		0
6	0.00	68	91	0			0
7	0.00	62	92	0		Cloudy	0
8	0.00	66	97	0		Clear	0
9	0.00	68	99	0		Clear	0
10	0.00	66	98				0
11	0.00	65	95	6	12:00 p.m.– 6:00 a.m.	Clear	0
12	0.80	70	95	0		Clear	0
13	0.10	61	77	4	4:00 a.m.– 8:00 a.m.		0
14	0.00	49	89	5	3:00 a.m.– 8:00 a.m.		0
15	0.00	59	89	3	5:00 a.m.– 8:00 a.m.	Clear	0
16	0.00	68	93	0			0
17	0.00	62	86	0			0
18	0.00	57	80	0		Decidedly cloudy entire day	0
19	0.00	65	92	6	1:00 a.m.– 8:00 a.m.	Clear	0
20	0.81	67	84	24	8:00 a.m.– 8:00 a.m.	Cloudy, gentle rain all day	0
21	0.00	66	86	16	8:00 a.m.–12:00 a.m. 8:00 p.m.– 8:00 a.m.	Cloudy	0
22	0.00	68	88	2	8:00 a.m.–10:00 a.m.	Cloudy, heavy fog	+Heavy

[a] For 24 hours ending at sunset of date indicated.

METEOROLOGICAL DATA

Data are given in table 1 for the period from July 24, when the counts were begun, until August 22, when identity of most of the lesions was definite because of sporulation of the pathogen. Temperatures recorded were shade temperatures. A continuous record of the relative humidity and temperature was made by a Friez hygrothermograph placed 2 feet from the ground in a tobacco field on the Oxford experiment station farm.

DISCUSSION

General

In considering the observations recorded, it is interesting to note that the maximum number of spots occurring on any leaf was 8 (Fig. 1), whereas, in parts of Australia (14), in Ceylon (18), and perhaps in other places where conditions are favorable for the development of the disease, 100 spots or more per leaf are encountered in flue-cured tobacco. During some seasons in North Carolina, where there are decided variations in the amount of rainfall and the number of cloudy days, many more spots per leaf occur than the maximum recorded for 1941.

In attempting to draw conclusions from the results listed, the factors that modify infection, such as light, moisture, temperature, prevalence of inoculum and susceptibility of leaves must be considered.

Sources and Distribution of Inoculum

Reports dealing with sources of inoculum of cercospora leaf spot of tobacco show that these sources differ according to varying locations and cultural practices (17, 21, 25, 8, and 3).

The presence of species of wild tobacco, susceptible to cercospora infection in the vicinity of tobacco fields, is listed as a source of inoculum (3). It is suggested that until more extensive cross-inoculation tests are made, the possibility of host plants other than those listed by Hill (3) serving as sources of inoculum, should not be overlooked. However, regarding airborne spores Park (17) has shown that cercospora spores were not transmitted, in a viable condition, as much as 100 yards by air currents.

Inasmuch as cercospora is known to be seed-borne (25), it is possible that spores that caused the spots counted on July 24, were produced on lesions of the lower leaves of the young plants in the field or could have been present on the seedlings at the time of transplanting. In such case, it is probable that more spores would have reached the lower than the upper leaves during the period favorable to infection. The same would have been true had the soil in the field, a source considered by Park (17) of primary importance in Ceylon, been responsible for the outbreak.

Increased Susceptibility of Lower Leaves and Varietal Differences in Degrees of Spotting

Experimental work to determine whether there was an equal distribution of inoculum from the uppermost to the lowest leaves on the stalks was

not done, nor was inoculum artificially applied to insure its equal distribution on leaves at all levels on plants under observation. Observational evidence, however, permits the conclusion that the lower leaves were more susceptible to invasion by the fungus than the upper leaves.

The counts (Fig. 1) show unquestionably that a greater number of spots were present, on a given date, on the lower than on the upper leaves. It is the generally expressed opinion, though not supported by experimental evidence, that the lower a tobacco leaf is on the stalk, and consequently the riper, the more susceptible it is to cercospora infection (6, 4, 13, 14, 7, 24). This opinion also accords with observations by Shear (20) in regard to physiological spotting of flue-cured tobacco leaves and those of Anderson (1) in regard to the John Williams Broadleaf spot of shade-grown cigar tobacco. Differing observations, however, in respect to cercospora spotting are expressed by Hornby (10) and Schweizer (19).

An unpublished report on inoculation studies of *Alternaria longipes* (12) contains evidence that the fungus involved is capable of invading leaves or sections of leaves that have reached a certain degree of maturity, but that under precisely the same conditions otherwise cannot establish itself on younger leaves or portions of a leaf.

Mandelson (13) has presented experimental evidence that more rapid destruction of leaf tissue by *Cercospora nicotianae* takes place in mature than in less mature leaves. This accords with the statement by Mohr (15) in Sumatra, that plants of *Nicotiana triplex*, which, in contrast with other Deli varieties and foreign tobaccos, showed some degree of resistance to cercospora spotting, had no fewer spots than less resistant varieties, but that the spots were smaller.

It is known that leaves at the same stalk level on different plants of one variety, grown under presumably comparable conditions, ripen on different dates. Likewise, certain varieties ripen earlier than others. Definite criteria for judging ripeness have not been established. Consequently, data other than stalk position regarding the condition of leaves at the time counts were made, are not available for correlation with counts of spots.

The difference for the 2 varieties having the most widely divergent counts for the tenth leaf from the top of the plant is shown graphically (Fig. 1). A varietal difference in susceptibility seemed on first thought a possible explanation. Statistical analyses showed that Gold Dollar, the variety having the greatest average count for the tenth leaf from the top, differed significantly in this respect from Special 400, Adcock Pinkney Arthur, Mammoth Gold, Coker's 1940 Selection and Jamaica Huggins. Due to the rapid ripening and harvest of leaves in the field under observation, counts of spots on leaves at stalk levels lower than the tenth were not obtained in sufficient numbers to justify conclusions in regard to them. Counts at any leaf position for remaining 25 varieties did not differ significantly from those of Gold Dollar.

An uneven distribution of inoculum could have accounted for the differences in counts obtained for different varieties. However, in the case of

the field under observation, presumptive evidence that an even distribution of inoculum occurred over the entire variety field is presented in the counts obtained for variety 401 in an adjoining field and in the field in question. Counts of spots on 100 leaves, at the level of the tenth from the top of the plant, variety 401, widely distributed in a 2-acre field, did not differ significantly from counts for leaves at the same stalk level, variety 401, at a distance of 1000 ft., in the variety field. There is admittedly a remote chance that a gradient could have existed across the field, in the concentration of inoculum. This possibly could have existed by coincidence, depending upon the source of inoculum, for the variety field and not for the field compared to it. Strong evidence that this did not occur and that an even distribution of inoculum, whatever its source and the means of distribution, prevailed over the entire variety field for any given stalk position, is found in the examination of counts for Gold Dollar growing in two rows along the edge of the field and in two rows two-thirds of the distance across the field. Counts for any leaf position of this variety were practically the same for both locations in the field.

However, the differences between varieties noted for the tenth leaf from the top of the stalk were not found in the case of leaves at higher levels, for example, leaves 7, 8, and 9 from the top of the plant. One exception to this was in the case of the eighth leaf from the top of the plant in Jamaica Huggins. This makes it appear unlikely that varietal resistance exists among these different types because presumably it should operate not only for the lowest leaf on the stalk, but also for the next higher and for leaves at all levels. On the other hand, the fact that counts (Fig. 1) at all stalk levels downward through the ninth leaf were essentially the same for the varieties that differed widely in the count for the tenth leaf from the top of the plant, is presented as an indication that the condition of the leaf as regards ripeness determines its degree of susceptibility to cercospora spotting.

The present data and observations emphasize the necessity for careful scrutiny of the evidence for the existence of differences in varietal resistance. The evidence should be examined from the point of view of even distribution of inoculum, equally favorable atmospheric conditions for infection at any given stalk level and equal ripeness of leaves compared. In regard to distribution of inoculum and equally favorable conditions for infection, leaves from all the plants for any given stalk position were probably comparable at any given stalk level. However, the remote possibility that the tenth leaf from the top of the plant in Gold Dollar was, on the average, lower on the stalk than was the tenth leaf in the varieties from which it differed significantly, should be considered in an attempt to explain differences in numbers of spots. If this had been true, and the soil an important source of inoculum, a higher count would have been expected for the lowest leaves. In such case the amount of inoculum reaching the ascending leaves would have been proportionately greater in this variety than in the others. Dif-

ferences in amounts of spotting by spread of inoculum upward from the lowest leaves by means of air currents, insects, and spattering rain might be accounted for by differences in infection of seedlings when removed from the seed bed. The influence of these factors on the infections observed is unknown.

The leaves of the different varieties that were compared, though at the same stalk levels, were not known to be of equal ripeness. It is likely that varietal differences known to condition the time necessary for maturing of leaves account for the differences observed in susceptibility to spotting. It is not possible to claim the existence of definite evidence for the presence of varietal resistance independent of maturity of leaves, on the basis of the available data. This is in agreement with the decision of van der Weij (24) who made observations that he thought possibly indicated varietal resistance. In order to secure definite evidence of differences in varietal susceptibility to cercospora leaf spot, it would be necessary to determine by preliminary inoculation tests, the chronological age at which leaves of different varieties developed a maximum number of spots under standardized conditions. Then, if standardized conditions could be maintained throughout the tests, counts of spots, made for leaves at certain stalk positions for each variety on the date when leaves in these positions were known to be most susceptible, would be significant in comparing varieties for resistance to spotting.

SUMMARY

An outbreak of leaf spot caused by *Cercospora nicotianae* on flue-cured tobacco occurred in the fields at the Tobacco Experiment Station, Oxford, North Carolina, in 1941. Most of the lesions remained atypical in appearance during the greater part of an unusually dry, hot growing season and would not have been recognized macroscopically on the basis of the classic descriptions of mature frog-eye spots. Cultural studies were made to determine identity of the fungus. Identity of the causal fungus was definitely confirmed when a prolonged rainy period during the latter part of the season induced abundant sporulation of the fungus in a large percentage of the lesions under observation.

Several varieties were almost free of spots for the tenth leaf from the top of the plant in contrast with certain other varieties. Definite evidence of differences in varietal susceptibility cannot be claimed as the leaves compared, although of the same chronological age, were not known to be of equal ripeness.

Evidence is presented to show that apparent differences in susceptibility of two varieties were probably due to the earlier ripening of the lower leaves of one variety than of those of the other, rather than to a specific resistance of one variety to the pathogen.

In all varieties the upper 5 leaves showed definite spotting but markedly less than the lower leaves.

In all varieties a progressively higher count per leaf, the lower its position on the stalk, was noted.

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SOME RELATIONSHIPS BETWEEN POTATO YELLOW-DWARF VIRUS AND THE CLOVER LEAF HOPPER

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INTRODUCTION

It is the purpose of this note to make available hitherto unpublished miscellaneous information on the clover leaf hopper, *Aceratagallia sanguinolenta* Prov., and the potato yellow-dwarf virus, *Marmor vastans* H. var. *vulgare* Black. Data on the transmission of the virus by nymphs, the failure of the virus to affect insect mortality, and the incubation period of the virus in crimson clover, *Trifolium incarnatum* L., were accumulated incidentally during studies on genetic variation in the ability of the clover leaf hopper to transmit potato yellow-dwarf virus (3). In addition, the paper includes an account of experiments on the incubation period of the virus in the insect, the frequency of transmission of virus, and the failure of the virus to pass through the insect egg. These experiments were either performed too late for inclusion or were unsuitable for inclusion in earlier papers.

TRANSMISSION BY NYMPHS

Transmission of potato yellow-dwarf virus by adults and nymphs of the clover leaf hopper has been observed in hundreds of cases in controlled experiments. In experiments on active and inactive races of the clover leaf hopper (3), the presence or absence of a cast skin was recorded whenever individual insects were transferred to fresh test plants. The instar or instars in which an insect had transmitted the virus was determined by counting these cast skins back from the last ecdysis. Failure to find a skin that actually had been cast would therefore result in recording an infection by an instar older than that in which the transmission took place. Thus, the small number of errors of this sort which may have been committed do not invalidate the conclusions drawn from the data. According to Watkins (6), the clover leaf hopper passes through 5 nymphal instars, and this number has been assumed for all insects in the present study, although in an experiment described below evidence for some variation in the number of instars was obtained. Altogether, 0 transmissions were recorded for the 1st instar, 1 for the 2nd, 17 for the 3rd, 61 for the 4th, and 227 for the 5th. It seems safe to conclude, at least, that transmission occurred in the 3rd, 4th, and 5th nymphal instars. There is a remote chance that the record of a single transmission by a nymph in the 2nd instar may be due to a contamination or a mistake in recording data. The data should not be construed as indicating that transmission does not occur in the 1st instar because in the experiments from which these data were derived the earlier the instar the fewer the insects tested.

FAILURE OF VIRUS TO AFFECT INSECT MORTALITY

It is interesting that not a single plant virus has been found to affect its insect vector in any way other than to render it infective. In an attempt to discover whether or not the potato yellow-dwarf virus had a deleterious influence on the clover leaf hopper, the mortality of the leaf hoppers in the genetic studies (3) was analyzed in relation to their infectivity. The odds for any difference not being due to chance alone were derived by the use of the 4-fold table. The chi-square values were translated into odds by using corresponding probability values in Fisher's (4) or Yule's (7) tables. To facilitate the analysis, neither insects dying as nymphs nor any of the hybrids between the active and inactive races were included. Insects dying on their first test plant also were not included, because they were considered to have been inadequately tested for infectivity. Analysis of the data on the

TABLE 1.—*Insect mortality in various population groups*

Infectivity	Race	Total insects	Insects dying	Percentage of insects dying	Odds that difference not due to chance alone
Infective	Active	562	81	14.4	
	Inactive	78	8	10.3	
	Total	640	89	13.9	
Noninfective	Active	163	32	19.6	> 100 : 1[a]
	Inactive	698	76	10.9	
	Total	861	108	12.5	
Both	Active	725	113	15.6	97 : 1[a]
	Inactive	776	84	10.8	

[a] These were the only differences found to be significant.

rest of the insects reveals that out of 640 infective individuals 89, or 13.9 per cent, died, whereas out of 861 noninfective individuals 108, or 12.5 per cent, died. This difference is not significant (odds 1 : 1) ; that is, the chances were only 1 : 1 that the difference was not fortuitous. However, when the infective and noninfective insects in each race were considered separately (Table 1), the data revealed a possible tendency for a higher death rate among noninfective than among infective insects in the active race (odds 5 : 1). This difference may be fortuitous or, if there be such a tendency, it may be nothing more than a reflection of the probability that the death of some insects during the test period prevented them from shifting from the noninfective to the infective group. If the data are considered from the standpoint of race (Table 1), it is apparent that there is a significant difference between the two races. More deaths occurred in the active race, independently of whether the insects were infective or not. The higher death rate in the active race is attributed to the effects of inbreeding which fortuitously were more harmful in the active race than in the inactive one. When the data were reconsidered on the basis of sex, it was found that out of 731 males 103, or 14.1 per cent, died, and out of 770 females 94, or 12.2 per cent, died. This

difference is not significant (odds 2:1). The data reveal no evidence that the potato yellow-dwarf virus hastens the death of clover leaf hoppers transmitting it.

INCUBATION PERIOD OF THE VIRUS IN CRIMSON CLOVER

During studies on the genetic variability of the clover leaf hopper in transmitting potato yellow-dwarf virus (3), the week in which each clover test plant developed symptoms was recorded. These data have been collected and arranged in table 2. The test plants upon which the 5th generation of insects were tested were omitted from the table, since weekly records were not made on them. Usually, insects were kept on test plants for 1 week; if the period exceeded 1 week the resulting data were also omitted

TABLE 2.—*Incubation period of potato yellow-dwarf virus in crimson clover*

Experimental period	Insect generation tested	Number of plants developing symptoms in the				
		1st week	2nd week	3rd week	4th week	5th week
		after the inoculation period of 1 week				
Feb. 3, 1937 to Apr. 28, 1937	P	1	36	15	7	0
Apr. 28, 1937 to June 9, 1937	G_1	0	22	11	4	0
Sept. 1, 1937 to Nov. 10, 1937	G_2	2	29	10	7	1
Dec. 4, 1937 to Feb. 27, 1938	G_3	3	159	164	70	21
Mar. 18, 1938 to May 20, 1938	G_4	19	96	43	16	10
Oct. 3, 1938 to Nov. 30, 1938	G_6	1	45	57	33	13
Dec. 15, 1938 to Mar. 2, 1939	G_7	2	61	79	53	29
Apr. 27, 1939 to June 15, 1939	G_8	1	17	33	16	8
June 29, 1939 to Aug. 31, 1939	G_9	3	80	122	42	18
Total		32	545	534	248	100

from the table. The experimental period (Table 2) includes the period during which the plants were inoculated and the subsequent period during which they were observed in the greenhouse. Incubation periods were reckoned from the middle of the feeding period of 1 week. For example, if a plant developed symptoms during the following week, the fact was recorded in table 2 under the 1st week. This method of recording the data is believed to give a fairly accurate picture of the variation in the incubation period. However, it must be pointed out that no case of an incubation period as short as one week was observed, *i.e.*, no plant was observed to have symptoms of disease when the insect was removed from it at the end of the 1-week feeding period. It is apparent from the table that the incubation period is quite variable and that most plants develop the first symptoms of the disease in

the 2nd and 3rd weeks. It is also evident from the totals that some plants may be expected to develop symptoms after the 5th week but that this number will not be an important fraction of the plants inoculated.

INCUBATION PERIOD IN THE INSECT

As the result of a preliminary experiment, the incubation period of potato yellow-dwarf virus in the clover leaf hopper was reported in an earlier paper as being about 9 days (1). Since that time additional experiments have been performed. The experiments are summarized in table 3. Altogether, 8 experimental and 1 control series of transfers were carried out. In all series the nonviruliferous insects were fed on potato plants (*Solanum tuberosum* L. var. Green Mountain) for 24 hours before beginning the series of daily transfers on fresh healthy test plants. During this preliminary 24 hours, the control series was fed on healthy plants, the others on the tips of stems in the acute stage of yellow dwarf. In series 2 the experiment was begun with adults, in all others with nymphs. Many of the nymphs changed to adults before the transfers were completed. In series 1, 2, and 3, young healthy potato plants were employed as test plants; in the other series, crimson clover plants were used. The clover test plants had about 4 trifoliate leaves when the insects were added. The number of insects surviving at each transfer and the presence or absence of yellow dwarf in the test plants are given in table 3. It is evident from the table that the potato yellow-dwarf virus had a variable incubation period in the clover leaf hopper, a minimum of 6 days (series 4) and a maximum of 10 days (series 6, 7) being detected. It seems probable, however, that if incubation periods had been determined for single insects much longer intervals would have been recorded for some individuals.

This seems the more likely if one considers data obtained by testing single insects in the genetic studies (3). In these studies there were 133, 65, 42, 42, and 8 insects that failed to transmit until the 2nd, 3rd, 4th, 5th, and 6th weeks, respectively, after completing their feeding period on diseased plants. It is believed that these delays probably represent long incubation periods because it seems probable that, in most cases, these insects did not transmit virus during the period they were reared on diseased plants. However, because the period the insects fed on diseased plants varied from about 2 to 4 weeks, it is impossible to be certain that these long periods represent incubation periods and not long lapses between transmissions. To make certain of such a long incubation period as the 6-week period indicated above would require the testing of single insects on a large scale after permitting them to pick up virus for one day only.

FREQUENCY OF TRANSMISSION

To determine the frequency with which the clover leaf hopper transmits potato yellow-dwarf virus, 2 experiments were carried out in which each of several infective insects was transferred daily to a fresh healthy crimson

TABLE 3.—*Incubation period of potato yellow-dwarf virus in the clover leaf hopper*

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Test plant	Series	Day	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26
Potato	Experimental 1	Number of insects	127	127	124	121	121	121	121	119	119	110	108	108	105	96	81	63	61	50	44	37	27	24	21	21	21	21
		Plant reaction	−	−	−	−	−	−	−	−	−	+	*	−	*	*	*	*	*	+	*	*	−	−	+	+	+	−
	Experimental 2	Number of insects	100	98	95	95	91	85	83	81	80	77	73	65	64	61	60	57	55	53	48	47	43	42	39	37	36	
		Plant reaction	−	−	−	−	−	−	−	−	+	−	−	−	−	−	+	−	+	+	−	−	−	−	+	+	−	
	Experimental 3	Number of insects	128	112	111	103	100	100	98	98	98	98	98	98	96	93	92	83	80	73	69	62						
		Plant reaction	−	−	−	−	−	−	−	+	+	+	+	+	+	+	+	+	+	+	−	+						
Crimson clover	Experimental 4	Number of insects	81	74	70	66	63	60	60	59	59	56	55	54	54	54	54	54	54	54	51	51						
		Plant reaction	−	−	−	−	−	−	+	−	+	+	+	+	+	+	+	+	+	+	+	+						
	Experimental 5	Number of insects	100	94	85	78	72	69	64	59	57	57	55	55	52	50	48	48	48	47	47	47						
		Plant reaction	*	*	−	−	−	−	−	−	+	+	+	−	−	−	−	−	+	−	−	+						
	Experimental 6	Number of insects	100	96	93	89	79	78	65	60	60	59	59	58	57	57	57	54	53	53	53	53						
		Plant reaction	−	−	−	−	−	−	−	−	−	−	+	+	−	+	+	+	+	+	+	+						
	Experimental 7	Number of insects	100	99	97	97	90	73	64	60	60	59	57	56	56	56	56	53	51	51	51	50						
		Plant reaction	−	−	−	−	−	−	−	−	−	−	+	+	+	+	−	−	+	+	+	+						
	Experimental 8	Number of insects	100	95	95	93	91	91	86	86	83	83	79	78	78	77	75	75	73	73	72	72						
		Plant reaction	−	−	−	−	−	−	−	−	−	+	−	−	+	−	−	+	+	+	−	+						
	Control 1	Number of insects	95	88	86	83	75	73	63	59	59	58	58	57	55	51	51	49	49	48	48	48						
		Plant reaction	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−	−						

* = plant died due to causes other than yellow dwarf. + = plant developed yellow dwarf. − = plant remained healthy.

clover seedling. In both experiments the insects were members of the active race (3), the insects of the 1st and 2nd experiments coming from the 7th and 8th generations, respectively. In both cases the insects were hatched and reared on diseased crimson clover and began their series of daily transfers as nymphs. In the 2nd experiment data as to sex and ecdyses were recorded and 2 control plants to which no insects had been added were included each day. Plants were held for observation for at least 6 weeks after the insects were placed on them. The results are presented in table 4.

It is apparent from the table that there is great variation in frequency of transmission between different insects and within the same insect at different times. Insect 8, experiment 2, transmitted only on the 16th and 17th days that it was tested on healthy plants and not on any of the subsequent 27 days that it was tested. On the other hand, insect 12, experiment 1, infected 25 out of the 30 plants on which it was tested. It infected as many as 10 successive plants. It is apparent that the virus remains in the insect through ecdysis; other than that, there is no obvious relation between ecdysis and transmission. There are many periods of several days between transmissions. For example, insect 12, experiment 2, transmitted only on the 8th, 24th, and 40th days. Insect 11, experiment 2, transmitted on the 10th day and then failed to transmit until the 35th day, more than 3 weeks later. On searching the data connected with the genetic studies (3), it was found that there were many such lapses in transmission. Altogether, there were 149 cases of a lapse of 1 week, 36 cases of a lapse of 2 weeks, and 8 cases where the lapse lasted for 3 weeks. The presence of some weed seedlings growing at random throughout the cages may account in part for lapses of transmission in the genetic studies (3). This, however, could not be a factor in the experiments in which the insects were transferred daily, since the pots were always carefully weeded before the plant was caged and the insect added.

The experiment also provides evidence that active insects remain infective for at least 44 days under conditions where it is very improbable that they could acquire fresh virus from plants. In other preliminary experiments the insects remained infective for at least 52 days while feeding on rye. It has been reported earlier (2) that the leaf hoppers remain viruliferous while hibernating without access to plants for at least 167 days, that overwintering adult leaf hoppers collected in the field in the early spring were infective, and that virus could be demonstrated in the body of the insect in any season. It seems clear from these various observations that the potato yellow-dwarf virus is retained by the clover leaf hopper for long periods.

FAILURE OF VIRUS TO PASS THROUGH THE INSECT EGG

Fukushi (5) has reported the only known case in which a plant virus passes from parent to offspring through the egg of the insect vector. To ascertain whether or not the potato yellow-dwarf virus passes from parent to young by way of the egg or sperm, an experiment was designed to test

TABLE 4.—*Frequency of transmission of potato yellow-dwarf virus by individual clover leaf hoppers*

Experiment	Insect	Sex	Day 1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44
1	1	Undetermined	–	–	–	–	–	–	–	D																																				
	2		+	–	+	+	+	+	–	+	–	D																																		
	3		–	+	+	+	–	+	+	–	–	–	D																																		
	4		–	–	+	+	–	+	+	+	+	+	D																																		
	5		–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	D																								
	6		–	–	–	–	+	–	–	+	–	–	+	–	–	–	–	–	–	–	–	+	D																								
	7		+	–	–	+	–	+	–	+	+	+	+	+	+	–	–	+	–	+	–	–	–	D																						
	8		+	+	+	–	+	+	–	–	+	–	+	+	+	+	–	–	+	+	+	+	+	D																						
	9		–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	D																		
	10		–	–	–	–	+	+	–	+	+	+	–	+	+	+	–	+	+	–	–	+	+	+	+	+	+	L																	
	11		+	+	+	+	–	+	–	+	+	+	+	+	+	+	+	+	–	+	+	+	+	–	–	+	–	+	+	+	+	–													
	12		–	+	+	+	+	+	+	+	+	+	–	–	+	+	+	+	–	+	+	+	+	+	+	+	+	+	+	–	+	+													
2	1	♀	–	–	–	–[c]	–	+	–	D																																				
	2	♂♀	–	+	–	–	–[a]	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	+	+	–	–	–	+	–	–	D														
	3	♀	–	–	–[a]	+	–	–	+	–	–	+	–	+	–	–	+	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	–	+	+	D		
	4	♀	–	–	–	–	–	–	–	–	–	–	–	–[a]	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	–	–	–	+	–	–	–	–	+	–	+
	5	♂	+	+	–	–[a]	–	+	+	–	+	–	+	+	–	–	–	–	+	–	+	–	–	–	–	–	+	–	+	+	+	+	+	–	+	+	–	–	–	–	+	–	+	–
	6	♀	+	–	–	–[a]	–	–	+	–	+	–	–	+	–	–	–	–	+	–	–	–	–	–	–	+	+	–	–	–	–	+	–	–	–	+	–	–	+	+	–	–	–	–
	7	♂	–	–	–	–	–[a]	–	–	–	–	–	–	+	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	+	–	–	–
	8	♂♀	–	–	–	–	–[a]	–	–	–	–	–	–	–	–	–	–	+	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	9	♀	–	–	–	–[a]	–	–	–	–	–	–	+	–	–	–	–	+	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	+	–	+	–	–	–
	10	♀	–	–	–	–	–	–	–	–	–	–[a]	–	–	–	–	–	–	–	–	–	–	–	–	–	+	+	+	–	–	–	–	+	–	–	–	+	–	+	–	–	–	+	+	–
	11	♀	–	–	–	–	–[a]	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	+	+	–
	12	♂♀	–	–	–[c]	–	–	–	–	+	–	–	–	–	–[a]	–	–	–	–	–	–	–	–	–	–	+	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	+	–	–	–
	13	♀	–	–	–	–	–[c]	–	–	–	+	–	–	–	–	–	–	–	–	–[a]	–	–	–	–	–	+	+	–	+	+	+	–	–	+	–	–	–	–	–	–	–	–	–	–	–
Control	1		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
	2		–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

+ = plant infected. – = plant healthy. D = insect died. L = insect lost.
Superscript [c] = cast skin found, insect still a nymph.
Superscript [a] = cast skin found, insect now an adult.

the progeny of viruliferous parents before the progeny could acquire virus from infected plants. Three matings were made between known viruliferous individuals of the 6th generation of the active race (3). The number of plants infected by each parent varied from 1 to 4. In all, the 6 parents had infected 13 plants. Each female, after being mated, was transferred to an individual red clover plant (*Trifolium pratense* L.) suitable for the deposition of its eggs. It was transferred to a fresh plant about once a week. These plants were subsequently examined daily for nymphs, which were removed and placed individually on single crimson clover seedlings. In this way the nymphs were removed from the plant on which they were hatched usually before they were 24 hours old, occasionally after this age but before they were 48 hours old. Each of 121 surviving progeny was tested for 1 week on each of 7 successive crimson clover seedlings. Each test plant was observed in the greenhouse for 7 weeks after the insect was removed. None of the 847 test plants developed yellow dwarf. A few additional insects died before completing the test period of 7 weeks, but none of these infected any of the plants on which they fed. Transmission from parent to offspring did not occur.

Incidentally, in this experiment a record of all cast skins was kept. According to these records, 2 insects molted 6 times, 67 insects 5 times, 40 insects 4 times, 9 insects 3 times, and 1 insect twice in order to reach the adult stage. As some skins may not have been found, it is felt that the results on the lower number of ecdyses may not be reliable. However, it seems safe to conclude that the normal nymph has 5 instars, the same number reported earlier by Watkins (6).

The writer has thus far always obtained nonviruliferous nymphs when viruliferous adults were caged on alfalfa (*Medicago sativa* L. var. Grimm). This procedure has been used repeatedly with success when nonviruliferous progeny was desired. The results confirm the failure of the virus to pass from parent to young through the egg and indicate that alfalfa is either immune from the virus or very resistant to infection.

SUMMARY

Clover leaf hopper nymphs in the 3rd, 4th, and 5th instars transmitted the potato yellow-dwarf virus in many instances. One record of transmission was obtained by a nymph in the 2nd instar.

No significant difference in mortality between infective and noninfective insects was observed.

The incubation period of the virus in crimson clover plants was variable. The majority developed symptoms in the 2nd and 3rd weeks after the feeding or inoculation period of one week. Some plants developed symptoms during the 1st week after the feeding period; others did not develop symptoms until the 5th week.

The incubation period of the virus in the insect was demonstrated to vary from 6 to 10 days. There is evidence that in individual insects the incubation period may be much longer.

Individual insects may infect crimson clover seedlings daily for at least 10 days. On the other hand, a lapse of many days between transmissions is common. In one case there was a 25-day interval between two transmissions by the same insect.

Insects transferred daily to fresh healthy clover plants remained infective for as long as 44 days. Insects fed on rye were still infective after 52 days.

Virus did not pass from parents to progeny through the eggs or sperms of the insect vector.

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AN ALTERNARIA DISEASE OF ZINNIA

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In the summer of 1934 specimens of an undescribed leaf spot of zinnias (*Zinnia elegans*) were deposited in the herbarium of the Cornell department of plant pathology, Cornell University, by John Dearness, who had collected the specimens a few days earlier in a garden in Ontario, Canada. The organism associated with the spots was tentatively referred to *Alternaria solani*, though no detailed study of the disease or the organism was made at that time. During the same summer, what appeared to be the same disease was noted in the floriculture gardens at Cornell University by C. E. F. Guterman, who established by controlled experiment the pathogenicity of the Alternaria strain involved. Unfortunately, no account of this work was ever published. The disease has recurred annually in the Cornell gardens and has increased so greatly in severity that it is now planned to abandon further culture of zinnias in these gardens until adequate, practical control measures can be devised. During the past 3 years the writers have received specimens of zinnias affected by the disease from gardens in many sections of New York State and have seen the disease in severe form in a commercial planting near New York City.

Recently (1936–1940), a zinnia disease, apparently identical with that herein described, has been reported by Weber (10) and Neergaard (7) in Denmark, and by Beaumont and Staniland (5) in England. Gram and Rostrop (6), earlier (1923), reported a seedling blight of zinnia in Denmark caused by *Macrosporium caudatum*. It is possible that the same disease was here involved and that the pathogen was incorrectly identified. Alternaria on zinnia in the United States has been reported from Florida (1), Connecticut (2, 3), and New York (4), though it is not known whether the diseases reported from Florida and Connecticut are the same as the one in New York. In the autumn of 1941, two independent reports of limited development of the alternaria disease in zinnia plantings in California were received.[1] Shortly after this manuscript was originally submitted for publication, the senior writer was advised by S. P. Wiltshire of the Imperial Mycological Institute of a paper by Pape (9) in which the alternaria disease of zinnia and its pathogen are described. Inasmuch as Pape's paper may not be readily available to American plant pathologists for some time to come, and because the disease appears to be a potentially serious threat to zinnia culture, the following account is presented.

[1] Letter dated September 27, 1941, from Dr. Kenneth Baker, University of California at Los Angeles; verbal communication from Dr. R. C. Allen, Cornell University, following visit to the Pacific Coast in summer of 1941.

SYMPTOMS OF THE ALTERNARIA DISEASE

On Foliage

Perhaps the most common and conspicuous symptom of the alternaria disease is the spotting of the foliage. Individual spots are at first circular

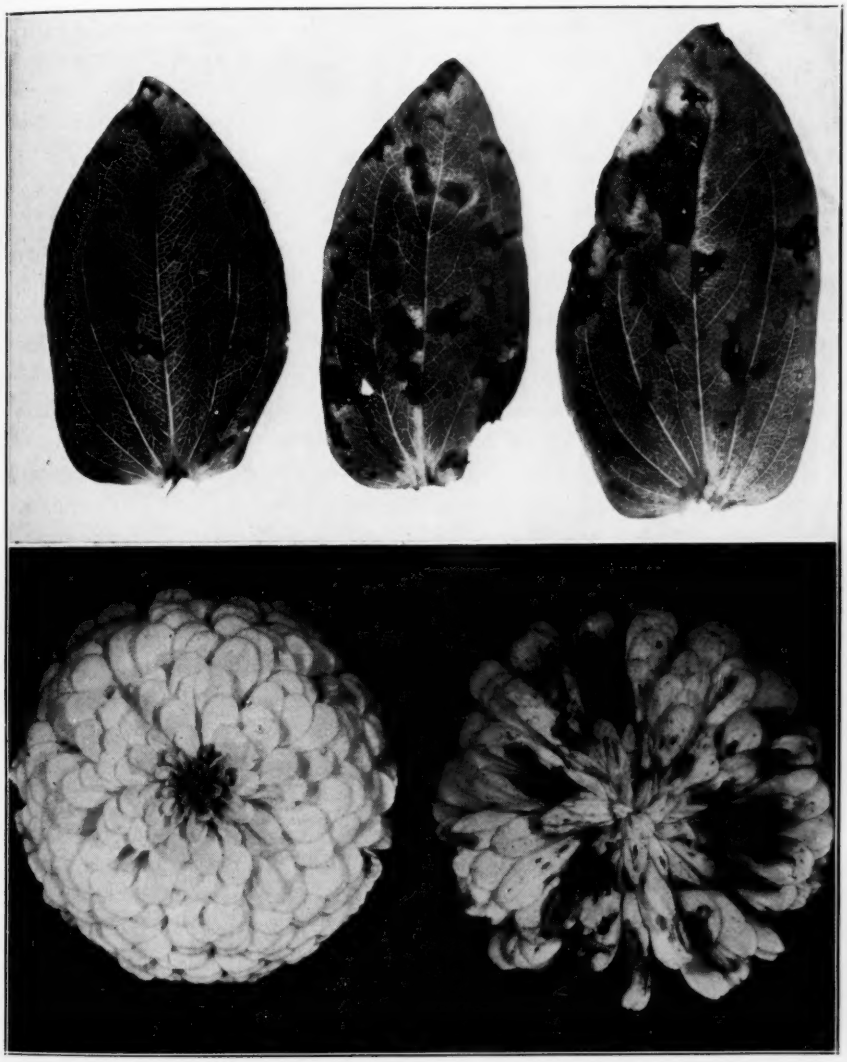

FIG. 1. Spotting of leaves and flower of white, dahlia-flowered variety of *Zinnia elegans* following natural infection with *Alternaria zinniae*.

in outline, but rapidly become irregular. The spots vary in size from 2 to 10 mm. in diameter (averaging about 5 mm.), are reddish-brown and may have greyish-white centers on the upper leaf surface (Fig. 1). Differentiation of margin and center is lacking on the lower surface. As the spots

increase in size and number, the affected leaves become brown and dry. Sporulation is often rather poor on leaf spots, but, under proper conditions, spores may be produced in abundance.

On Blossoms

Blossoms may be very severely affected by the alternaria disease. Brown spots 1 or 2 mm. in diameter and sometimes having greyish-white centers appear on the petal tissues of the conspicuous ray flowers. Sporulation is often profuse on these spots and secondary infections may be abundant. Affected petals soon darken and wither, and the blossoms are rendered worthless as cut flowers or garden specimens (Fig. 1).

On Stems

Numerous small reddish spots, sometimes with greyish white centers, usually are visible along the internodal areas of the stems of affected plants. These are rarely more than 1 mm. across, though they frequently show longitudinal elongation. Such spots are ordinarily superficial. Occasionally, through coalescence, rather large areas may be involved. Large lesions, frequently girdling the stems, often form at the nodes, due either to growth of the fungus inward from affected leaves or to infection occurring directly in the leaf axils. Unlike the internodal spots, the nodal lesions ordinarily do not remain superficial, and the distal portions of the affected stems may be killed by complete girdling at the nodes. Stem tissues often are invaded by growth of the fungus downward from badly affected blossoms. Basal cankers are common on the stems of plants in infected beds. These are dark brown to black and become sunken in the central portion. Fungous growth seems largely limited to the succulent cortical tissues, but complete girdling may occur. Affected plants often wilt completely, even when the basal cankers do not entirely girdle the stems. The root systems of such plants may remain healthy.

On Roots

Root infection, while the least conspicuous, is perhaps the most serious phase of the disease since it is not amenable to control by the relatively simple measures that might be employed to control infection on stems, foliage and blossoms. The cortical tissues of affected roots become dark grey, rot completely, and slough off, resulting in wilting and death of the plants. Isolation of the pathogen from infected roots is rather difficult, since secondary organisms follow in rapidly.

ETIOLOGY

Isolations made by various workers at Cornell during the past 7 years from typical lesions on zinnia leaves and stems have consistently yielded a rather uniform strain of a fungus of the genus *Alternaria*. The pathogenicity of this organism has been repeatedly proved by inoculation of healthy zinnias with mycelium and spores from pure cultures.

Development in Leaf Spots

Microscopic examination of cleared infected leaf tissue reveals the presence of light-colored intra- and intercellular hyphae within the lamina, and brown-walled conidiophores pushing through the stomata (Fig. 2). Spores of the fungus usually are visible on fresh specimens when atmospheric conditions favor sporulation. Such spores always appear to be borne singly on the conidiophores, but occasionally, on material which has been kept for a few days in a dry chamber, catenulation of spores is evident. Chains of as many as 8 spores have been seen. The spores are large, averaging 170–210 by 20–24 microns, with a beak usually more than twice as long as the

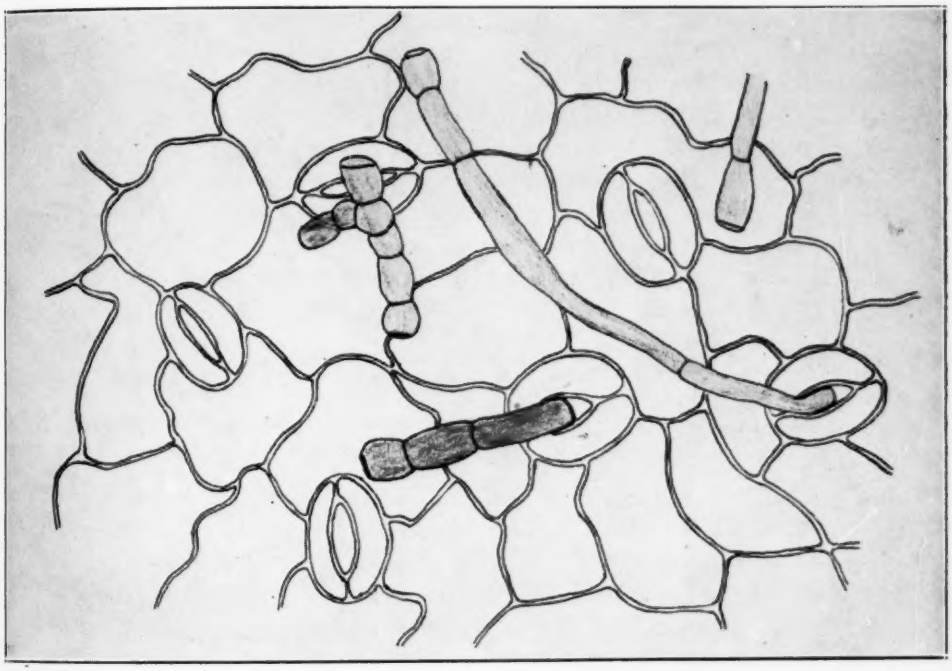

FIG. 2. Camera-lucida drawing of cleared portion of infected zinnia leaf showing conidiophores of *Alternaria zinniae* emerging through stomata.

body of the spore (Fig. 3, G). The body of the spore has numerous longitudinal and transverse septa. Stages in development of the spores are illustrated in figure 3.

Growth in Culture

The fungus grows rather rapidly in culture and may cover a 9 cm. Petri dish of potato-dextrose-agar in 7 or 8 days at optimum temperature. The rough mat of mycelium, about 2 mm. high, may have a narrow whitish margin, but the central growth rapidly assumes a dark grey color. A reddish pigment diffuses into the medium as the culture ages. The formation of this reddish pigment has been demonstrated by the junior writer to be

dependent upon the presence of sugars in the culture medium. Sporulation has been very poor on all culture media tested, including potato-extract agar, potato-dextrose agar, bean agar, oatmeal agar, pea agar, cornmeal agar and water agar. The optimum temperature for growth of the organism was found to be about 27° C. (81° F.).

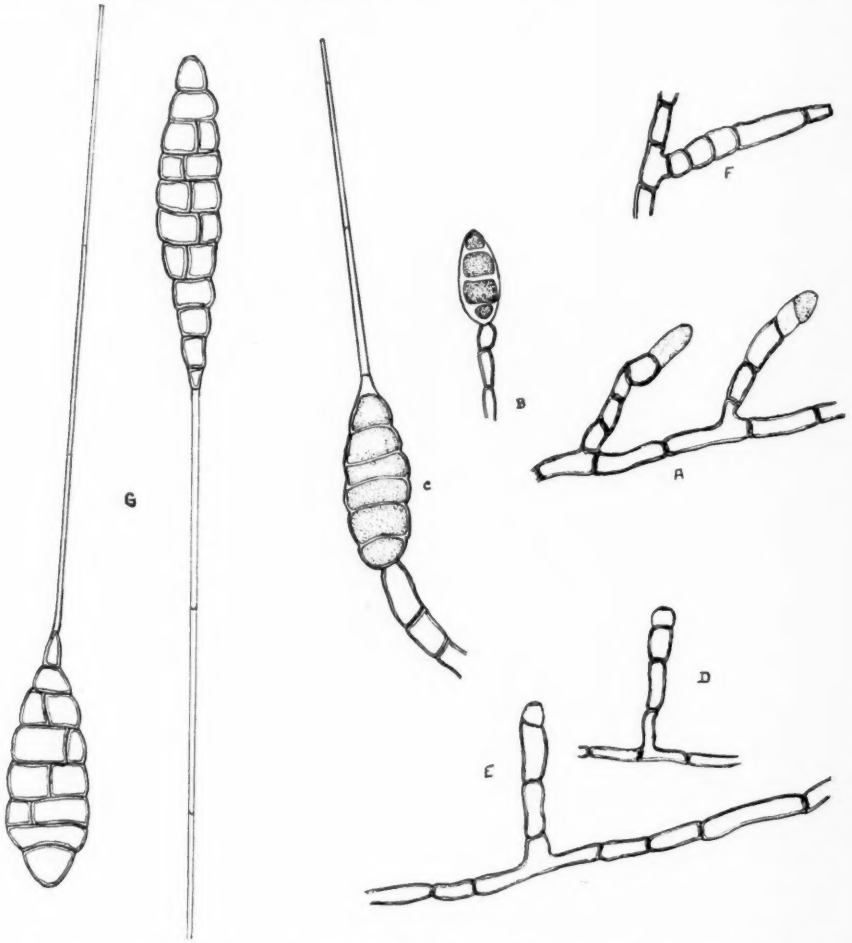

FIG. 3. Camera-lucida drawing showing development of conidia. A–C. Formation of conidia from terminal cell of conidiophores; material from potato-dextrose-agar culture. D–F. Conidiophores after abscission of conidia. G. Mature spores from naturally infected leaf.

The Pathogen

The zinnia pathogens described briefly by Weber (10), Neergaard (7) and Beaumont and Staniland (5) appear to be the same as that herein described. Furthermore, S. P. Wiltshire, in correspondence with the senior writer, has expressed the opinion that the fungus described by Pape (9) as *Alternaria zinniae* n. sp., is identical with ours. We may therefore conclude that the alternaria disease of zinnias, in both Europe and North America, is caused by *Alternaria zinniae* Pape.

PATHOGENICITY STUDIES

Although the pathogenicity of the Alternaria strain had been repeatedly proved by Cornell workers since 1934, a more detailed study of inoculation and infection was undertaken by the junior writer during the 1940–41 season. In order to avoid the variation which might result from the use of potentially variable spore inoculum taken from naturally infected field material, it was decided to use spore inoculum developed in culture from a single-spore isolate of the pathogen. Inasmuch as sporulation was very poor on all culture media tested and could not be induced by any of the methods commonly used for that purpose, a more effective method was sought. The following method proved satisfactory, although consistent results were not always obtained.

A dilute suspension of spores and mycelium in cooled, sterile 1 per cent water agar was poured in a thin layer in sterile Petri plates. Cheesecloth discs, previously cut to fit the plates and sterilized with hot air, were then placed three-deep on the surface of the agar in each plate, this operation being performed under a transfer hood. Moisture given off from the agar was absorbed by the lower discs of cheesecloth, leaving the upper disc comparatively dry. Spores were produced in abundance on the upper discs in 11 or 12 days and were readily removed by scraping in sterile water. The spores settled rapidly and the excess water was decanted without centrifuging. Spore inoculum thus obtained was applied in the leaf-infection study described below.

Relation of Time, Temperature, and Surface of Leaf to Incubation and Infection

The following experiment was designed primarily to determine the effect of temperature on establishment of infection and duration of incubation period, and, incidentally, to determine whether invasion occurs more readily through the upper or the lower leaf surface. Young zinnia plants, about 5 weeks old and approximately 4 inches tall, each bearing 2 pairs of fully expanded leaves, were used. Since trials at different temperatures had to be performed consecutively rather than concurrently, the actual age of plants used varied slightly.

The plants were marked for inoculation by imprinting 6 circles of india ink, about 5 mm. in diameter, on the upper surface of one leaf of each pair, and similarly imprinting 6 circles on the lower surface of the other leaf of each pair. There was thus a total of 12 upper-surface areas and 12 lower-surface areas marked on each plant. One drop of spore suspension was placed, by means of a finely drawn out pipette, on each marked area. The inoculum used for each temperature series was adjusted so that from 9 to 12 spores were present in each drop.

Six plants were used in each temperature series, the plants being placed in the constant-temperature infection chamber immediately following inoculation. One plant was then removed from the chamber every 6 hours

and placed on the greenhouse bench. Artificial means were not employed to hasten drying of the surface moisture, since observation indicated that natural drying was extremely rapid. Examinations were made periodically for 3 weeks, but after the second week no new infections appeared. The data are summarized in table 1.

These data indicate that the optimum temperature for infection lies above 65° F. and below 75° F., probably about 70° F. It is interesting to note that this is considerably below 81° F., the optimum for growth of the fungus on potato-dextrose agar. The data also indicate that the incubation period may be as short as 12 hours at 70–75° F., though consideration of the data for all temperature tests suggests that, at the temperatures studied, maximum infection is not reached with an incubation period of less than 24 hours. It has been the senior writer's experience that, unless artificially

TABLE 1.—*Effect of temperature, duration of exposure and leaf surface inoculated upon infection of leaves of Zinnia elegans by Alternaria zinniae*

Temp.	Surface	Duration of exposure in hours						Total No. lesions
		6	12	18	24	30	36	
65° F.	Upper	.....	.....	.....	.....	6	.....	14
	Lower	.....	1	.....	5	2	.....	
70° F.	Upper	.....	.....	1	7	8	2	56
	Lower	.....	4	1	12[a]	10	11	
75° F.	Upper	1	3	3	2	.....	3	38
	Lower	.....	4	3	6	6	7	
80° F.	Upper	.....	.....	5	3	2	1	22
	Lower	.....	.....	3	3	.....	5	
Total No. lesions		1	12	16	38	34	29	130

Total No. lesions, upper surface—47; lower surface—83.
[a] 12 lesions represent 100 per cent infection.

dried, moisture sufficient to permit germination and infection may remain on the leaf surface for a number of hours after it appears to the eye to be quite dry. Conclusions concerning the precise duration of the incubation period should not be drawn without further study. It is evident that invasion occurred more readily through the lower surface of the leaf than through the upper surface. No attempt was made to determine whether this was correlated with number of stomata, thickness of cuticle, microclimate, or other factors.

Stem and Root Inoculations

The following experiment was undertaken to test the pathogenicity of *Alternaria zinniae* to roots of zinnia plants. Fifteen 1-month-old zinnia seedlings were transplanted from seed flats to individual 3-inch pots of sterilized soil that had been infested by mixing in about a tablespoonful of alternaria inoculum. The inoculum had been prepared by growing the fungus in flasks of unmodified, sterilized moist greenhouse soil, then thoroughly mixing the soil-mycelium mass before using. Fifteen seedlings were

also transplanted to pots of sterilized soil which had been infested with inoculum of a Phytophthora isolate frequently obtained from decayed zinnia roots. In addition, 15 seedlings were inoculated with an isolate of Fusarium commonly obtained from decayed zinnia roots. Inoculation in this case was made by dipping the roots of the seedlings in spore suspension just prior to planting in the pots of sterilized soil. As controls, 15 uninoculated seedlings were planted in pots of noninfested sterilized soil. The roots of these seedlings had first been dipped in sterile water.

Within 12 days after inoculation, 7 of the plants of the alternaria series had died, showing typical root rot and stem decay. Only 4 of the plants of this series were alive after 6 weeks, and only one of these was in vigorous condition. None of the plants in the Phytophthora, Fusarium or control series became infected. Many of the plants of the Phytophthora series had remained somewhat stunted for 2 or 3 weeks, and had exhibited marginal scorching of the lower leaves, but all were definitely recovering after 6 weeks. *Alternaria zinniae* was successfully reisolated from roots of several of the dead plants in the alternaria series.

As a further check on the susceptibility of stem tissues, seven of the healthy survivors from the above experiment were inoculated by placing agar-mycelium inoculum of *Alternaria zinniae* in slit wounds made in the stems. Uninoculated slit wounds were similarly made in a like number of the healthy plants to serve as controls. Typical Alternaria lesions had developed on all 7 inoculated plants within 2 weeks and reisolation attempts were successful. All of the controls remained healthy. These tests conclusively demonstrated the ability of *A. zinniae* to infect the roots and stems of zinnia.

PERPETUATION AND DISSEMINATION OF THE PATHOGEN

Intensive studies of the perpetuation and dissemination of the pathogen have not been undertaken. Limited studies and circumstantial evidence, however, have demonstrated rather well that the pathogen may live over at least one winter on infested plant débris (or perhaps independently) in the soil or on its surface. The annual recurrence of the disease in Cornell plantings strongly suggested carry-over in the soil; but more conclusive evidence was obtained during the past season when half of a lot of seedlings was shipped to another location for planting in a private garden and the remainder kept for planting in the Cornell gardens. No evidence of the disease appeared in the new locality, whereas the entire planting in the Cornell gardens was destroyed by the disease before the first of July. It was further indicated in the above test that dissemination of inoculum is readily effected by means of cultivating tools, or the washing of soil, or both. The beds in which the Cornell planting was made had not been occupied by zinnias for over 4 years and were about 100 feet distant from the beds in which zinnias had been planted for the past 4 or 5 years. They were, however, prepared and cultivated with the same tools as the old infested beds and were several feet lower in elevation, so that some soil washing may well

have occurred. These modes of dissemination, while important in localized intensification of the disease, are probably of no consequence in its long-distance spread.

Available evidence strongly indicates that the pathogen is seed-borne. As noted above, blossom infection is usually severe whenever the foliage is infected. Sporulation on infected petal tissue is very abundant and surface contamination of seed harvested from infected blossoms would be inescapable. The following test, conducted by the junior writer, is suggestive that actual infection of the seedcoat may occur and result in dissemination of the pathogen as internal mycelium. Thirty-five zinnia seeds (var. Giant Mammoth Lavender) were taken at random from a seed packet obtained from a popular commercial seedhouse. These were surface-sterilized for a short period in 1–1000 mercuric chloride solution, washed in sterile water, and plated out on potato-dextrose agar. An Alternaria, indistinguishable culturally from typical leaf spot isolates, was obtained from 21 of these seeds. Inoculation tests proved this Alternaria isolate to be pathogenic to zinnia foliage, producing typical Alternaria lesions. A second test, with seeds of the same source and variety but from a different packet, failed to reveal the presence of Alternaria. Additional evidence that the fungus is seed-borne is offered by Neergaard (8), who reported good control of what is presumed to be the same disease by seed treatment with one of the organic mercury compounds (0.25 per cent Germisan).

CONTROL

Inasmuch as it seems evident that the pathogen may readily be borne in or on the seed, it is of first importance that flower-seed producers become acquainted with the disease, recognize its potential importance, and attempt to prevent its development in their plantings. Thus far, the disease appears to be of limited occurrence both in the seed-producing areas and in private plantings. It is obvious, however, that if the disease ever were to develop seriously in the seed fields, it would soon become widely distributed. It is possible that the comparatively rainless summers prevalent in the seed-producing areas on the Pacific Coast have provided and will continue to provide a natural check on the disease. The matter would bear investigation.

No study of special control methods for this disease has yet been undertaken, but the following logical suggestions are offered:

1. Seed should be treated with a fungicide (mercuric chloride dip, Semesan, cuprous oxide, or other) to reduce the hazard from inoculum borne on the seed surface.
2. Thorough field and garden sanitation should be practiced.
3. The longest possible rotation of field planting site should be employed.
4. Cultivating tools should be cleaned, and preferably sterilized, before using in new zinnia planting areas.
5. Seedlings and young plants should be treated frequently with a good protective fungicide, making an effort to obtain coverage of the lower surface of the leaves.

SUMMARY

A disease of garden zinnia, *Zinnia elegans* Jacq., causing spotting of the petals, foliage and stems, and rotting of the roots, has been under observation at Cornell University since 1934.

The disease is caused by *Alternaria zinniae* Pape.

Conidia of *A. zinniae* averaged 20–24 by 170–210 μ including beak, the beak commonly being twice as long as the body of the spore. Catenulation has not been observed under natural conditions.

The optimum temperature for growth of the fungus in culture was found to be about 27° C. (81° F.), whereas the optimum temperature for leaf infection was found to be about 70° F.

An incubation period of approximately 24 hours was required for the maximum development of leaf infection.

Invasion occurs more readily through the lower surface of the leaf.

Evidence indicates that the pathogen may be seed-borne and may survive at least one winter in or on the soil.

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A DESCRIPTION OF THE FUNGUS CAUSING COTTON RUST, AND A PRELIMINARY SURVEY OF ITS HOSTS

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INTRODUCTION

The fungus *Aecidium gossypii* E. and E., causing rust of cotton in the Southwestern States, has been designated by Arthur and others as synonymous with *Puccinia schedonnardi* Kell. and Swing.[1] In 1941 the senior writer reported the establishment of a connection between *Aecidium gossypii* and a Bouteloua rust.[2] The rust was tentatively determined as *Puccinia boutelouae* (Jennings) Holw., and specimens were sent to Purdue University for confirmation. The material was examined by G. B. Cummins whose findings indicate that the rust is not *P. boutelouae*, but probably an undescribed species with at least one character distinct from all other rusts found on *Bouteloua* spp. The outstanding difference is the occurrence of 3 equatorial pores in the urediospores of the new species rather than several scattered pores, as listed for the other Bouteloua rusts. Recently, photomicrographs have been made to show the presence and arrangement of pores of the urediospores, and these are in accord with the findings of Cummins. (See Fig. 2, B.)

Under greenhouse conditions 38 American commercial varieties of cotton proved susceptible to the rust in all stages of growth when inoculated with germinating telia. Very young cotton seedlings sometimes were killed when the sporidial shower was especially heavy. The hypocotyl, coytledons, and true leaves became completely covered with pycnial clusters, and the plants soon died. However, seedlings survived a moderate sporidial shower and produced aecial clusters on all exposed parts of the plant. Of the 3 Asiatic varieties of *Gossypium arboreum* L. tested, the var. *assamica* Watt and var. *sanguineum* (Hassk.) Watt were resistant; while the red-flower var. *nanking* (Meyen) Harland was mildly susceptible, and produced abundant anthocyanin around the pycnial clusters.

FIELD INFECTION

Under field conditions in Arizona the rust attacks the cotton crop immediately following the first summer rains. The time of attack varies according to rainfall and humidity but usually occurs in July. The severity of attack depends upon weather conditions and the amount of inoculum present. Ordinarily, the first attack is relatively light and may pass unnoticed, but with each succeeding rain additional infection occurs. Greenhouse experiments have shown that telial material will produce infection continu-

[1] Arthur, Joseph Charles. Manual of the Rusts in United States and Canada. pp. 143–144. 1934.

[2] Presley, John T. *Aecidium gossypii*. The aecial stage of *Puccinia boutelouae*. Phytopath. **32**: 97. 1941.

ously for at least 12 days. Several series of cotton seedlings were passed through an incubator, without changing the inoculum, on grass suspended above the seedlings. The last series, though not so heavily infected as some of the first series, showed typical pycnial clusters, and aecia developed from them.

The first symptoms of rust on the cotton plants are small orange-color spots on the upper surface of the leaves (Fig. 2, C). These spots contain the pycnia (Fig. 2, A) and soon become discolored. The pycnial ooze becomes brownish with age and anthocyanin is produced by the leaf around

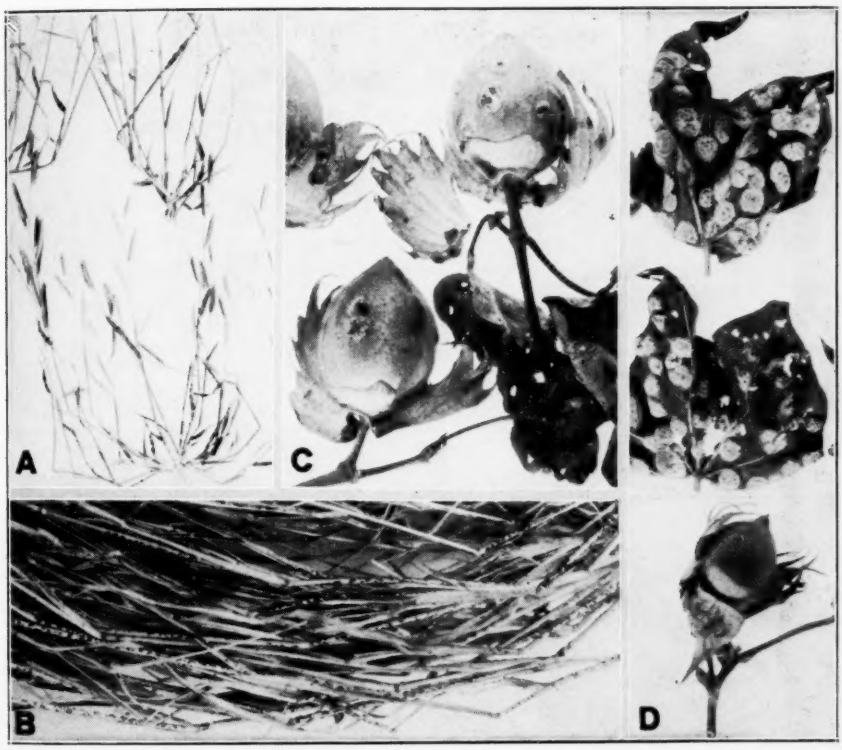

FIG. 1. A. Rust-infected grass (*Bouteloua rothrockii*) collected from uncultivated area; (B) from an irrigated cotton field. Somewhat reduced. C and D. Rust spots on cotton leaves, bracts and bolls. Note pycnia on upper surface of leaves and on bolls in C and aecial spots on under surface of leaves and bracts in D. Less than ½ nat. size.

the pycnial cluster (Fig. 1, C). Within a week aecia begin to form on the under surface of the leaf. The aecia are formed in circular spots surrounding the pycnia, and vary in size from 0.2–0.3 mm. in diameter (Fig. 2, F). At first the aecial clusters are deep yellow to orange, but, on exposure to the sun, soon fade and appear light-yellow to colorless (Fig. 1, D).

The shady, moist conditions in a cotton field favor the development of the rust on grass. The telia form soon after the uredia and mature early. Specimens on grass collected in late July proved viable and ready to reinfect cotton with the first favorable weather conditions.

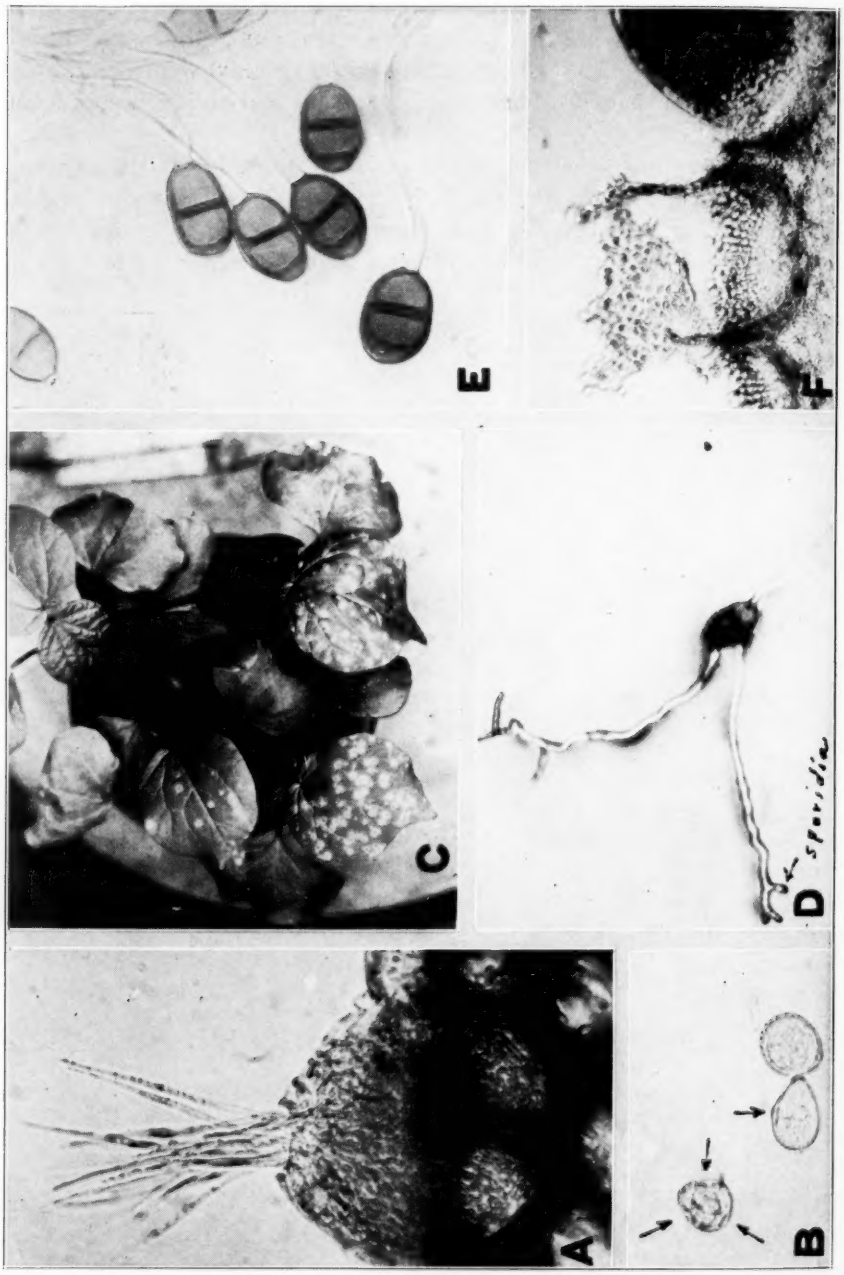

FIG. 2. A. Pycnium of the cotton rust fungus. ×400. B. Urediospores. Upper spore (vertical view). Note 3 pores shown in upper spore. Middle spore (horizontal view), note equatorial arrangement of pores. ×400. C. Pycnial spots on leaves of cotton seedlings after exposure to shower of teliospore from infected grass suspended above. ×about ½. D. Germinating teliospore showing promycelium emerging from both cells and developing sporidia on appendages near the ends. ×300. E. Teliospores. ×400. F. Cross section of aecia showing peridium and aeciospores. ×200.

The uredial stage of the fungus is rather inconspicuous, since it is formed largely on the leaves of the grass. The telia on the other hand are very conspicuous, sometimes covering the grass stems for several inches with prominent, dark pustules, which also appear among the uredia on the leaves. The teliospores are of the typical Puccinia type with two cells (Fig. 2, E). Both cells may germinate to form promycelia from which arise the sporidia (Fig. 2, D).

DESCRIPTION

The following description of the rust organism is based on pycnial and aecial material collected on cotton (*Gossypium hirsutum*) in a cultivated field at Hidden Valley, Arizona, in October, 1941. The telial and uredial materials were collected at the same time from *Bouteloua rothrockii* Vasey, growing adjacent to the cotton. A portion of the material from the same collection was submitted to Cummins and other portions were used to obtain infection on cotton seedlings in greenhouse tests.

Puccinia stakmanii n. sp. Presley

O. Pycnia amphigenous, also caulicolous, numerous, in small, sometimes discolored, slightly raised circular groups, crowded, punctiform, honey-yellow to cadmium-orange, becoming brownish, depressed, globose, 90–120 μ in diameter; ostiolar filaments 60 to 100 μ long.

I. Aecia chiefly hypophyllous, also caulicolous, in irregular groups surrounding the pycnia, 2–5 mm. in diam., somewhat crowded, cylindric, 0.4–1.0 mm. high, 0.2–0.3 mm. wide; peridium at first orange becoming yellowish or colorless, the margin lacerate and recurved; peridial cells quadratic or oblong, 17–30 × 11–20 μ, overlapping, the outer wall 6–9 μ thick, striate, the inner wall 2.5–4.0 μ thick, strongly echinulate; aeciospores globoid or broadly oblong, 13–19 × 18–25 μ; wall very pale yellow to colorless, 2–5 μ thick, finely verrucose, often appearing smooth.

II. Uredia mostly epiphyllous, internerval, oblong or linear, becoming confluent, 0.3 to several mm. long, early naked, pale cinnamon-brown, pulverulent, the ruptured epidermis apparent; urediospores globoid to broadly ellipsoid, 18–22 × 25–27 μ, the wall pale cinnamon-brown, 1.5–2.5 μ thick, moderately echinulate, the pores equatorial, usually 3.

III. Telia amphigenous and caulicolous, numerous, often crowded, rounded, elliptic or linear, becoming confluent, 0.3 to several mm. long, early naked, the ruptured epidermis at first conspicuous; teliospores oblong or broadly ellipsoidal, 19–25 × 26–38 μ, rounded at both ends or sometimes obtuse above, only slightly if at all constricted at the septum, this sometimes oblique or vertical; wall dark chestnut-brown, 1.5–2.5 μ at the apex 4–9 μ thick; pericel colorless, twice or thrice the length of the spore, sometimes attached at an angle.

Habitat: Pycnia and aecia on living leaves and stems of *Gossypium barbadense*, *G. hirsutum*, and many other species of *Gossypium* by inoculation; uredia and telia on living leaves and culms of *Bouteloua rothrockii* and other species of *Bouteloua* by inoculation; Arizona and Texas.

Puccinia stakmanii sp. nov. Presley

O. Pycnia amphigena etiam caulicola numerosa depressa gilva vel aurantiaca globosa diametro 90–120 μ in maculis parvis circularibus leviter elevatis.

I. Aecia praecipue hypophylla cylindrata alta 0.4–1.0 mm. lata 0.2–0.3 mm. maculis disparibus diametro 2 usque ad 5 mm; peridium aurantiacum deinde lutescens margine lacerato recurvato; sporae sphaeroidae vel late oblongae 13–19 × 18–25 μ.

II. Uredia plerumque epiphylla internervalia oblonga vel linearia longa 0.3 usque ad plura mm mature denudata; sporae sphaeroideae vel late ellipsoideae 12–22 × 25–27 μ pariete subfusco crassitudine 1.5–2.5 μ foraminibus equatorialibus plerumque 3.

III. Telia amphigena et caulicola numerosa saepe aggregata longa 0.3 usque ad plura mm mature denudata; sporae oblongae vel late ellipsoideae 19–25 × 26–38 μ septo aliququando oblique vel perpendiculare; pediculus non coloratus longitudine sporam duplo usque ad triplo excedens.

Type specimens are deposited in the Mycological collections of the Bureau of Plant Industry.

SURVEY OF THE HOST RANGE

The rust whose aecial stage occurs on all the principal varieties of both the upland and American-Egyptian cotton varieties grown commercially in the irrigated Southwest causes considerable damage in some seasons in limited areas. The telial stage of the rust occurs on species of *Bouteloua*. These grasses are commonly found in Texas, New Mexico, Arizona, and California. The continued expansion of the cotton acreage on virgin lands in the States where these grasses are native may bring further reports of damage by the disease.

Since cotton only recently was discovered to be the aecial host of the Bouteloua rust, it appeared desirable to make a preliminary survey of the plants susceptible to this stage of the fungus, as well as to explore the possibility of finding resistance in some cultivated variety of cotton. The survey was conducted in part at the U. S. Field Station, Sacaton, Arizona, and in part at the University of Minnesota in connection with the Division of Plant Pathology. Some interesting facts were disclosed by these studies, among them being the host range of the fungus. In the tests so far it has been possible to produce the aecial stage only on the genus *Gossypium*, and the uredial and telial stages only on the genus *Bouteloua*. It should be borne in mind, however, that the results here reported were obtained from tests on plants that were grown and inoculated under greenhouse conditions. Although differences were observed in susceptibility and resistance among the seedlings, the mature plant reaction under field conditions is known only for the 4 or 5 varieties of cotton grown commercially in the Southwest.

METHOD OF INOCULATION AND RESULTS

In making the inoculations the usual procedure used in cereal-rust investigations was followed. The telial material on bunches of grass was presoaked and suspended above the cotton seedlings in an incubator for 3 or 4 days. The cotton plants were then transferred to the greenhouse where they were placed under conditions of maintained high relative humidity. The pycnia usually appeared on the leaves and stems in 4 to 6 days following removal from the incubator. There was a wide variation in the number of pycnial clusters formed on any one leaf, since it is necessary for the sporidia to fall and penetrate the leaf tissue in order to produce infection. Apparently, there is no way to control accurately the number of sporidia that will fall and germinate on a particular surface, hence the criterion of susceptibility applied in the classification is rather arbitrary. If both pycnia and aecia were abundant the plant was considered susceptible. If only pycnia were formed the plant was considered mildly susceptible, and if there were neither pycnia nor aecia the plant was considered resistant. The different series of cotton plants subjected to inoculation were run either in duplicate or triplicate. A list of the cottons and other malvaceous and graminaceous plants tested and their classification according to resistance or susceptibility to artificial infection are given below.

LIST OF MALVACEOUS AND GRAMINACEOUS PLANTS, CLASSIFIED ACCORDING TO THEIR RESISTANCE OR SUSCEPTIBILITY TO ARTIFICIAL INFECTION FROM THE COTTON RUST FUNGUS

Plants Exposed to Germinating Telia

I. Cultivated Cottons

Gossypium hirsutum L.

***Acala (several strains)	***Durango	***Oklahoma Triumph
" Ballard	" Ewing's Long Staple	" Paris Big Boll
" Burnett	" Half and Half	" Petty's Toole
" Cleveland (several strains)	" Hartsville	" Rowden
" Coker's (several strains)	" Holden	" Sikes
" Columbia	" Kasch	" Spear's Upland
" College	" Kekchi	" Stoneville (several strains)
" Cooks	" Lone Star	" Texas Special
" D & P L (several strains)	" Meade	" Trice
" Davidson's Sunshine	" Mebaken	" Toole Perry
" Delfos (several strains)	" Mexican Big Boll	" Tuxtla
" Delta type Webber	" Miller	" Westex
" Dixie Triumph	" Missdel (several strains)	

G. barbadense L.

***Peruvian	***Sakellaridis	***Sea Island
" Pima	" S × P (Sakel × Pima)	*Zagora

G. arboreum L.

**Garo Hill	*Sanguineum	**Nanking

G. hopi Lewton

***Hopi

II. Cotton, Wild Species

**G. *anomalum* Wawra et Peyr.	**G. *harknessii* Brandg.	**G. *sturtii* F. v. M.
**G. *aridum* (Rose and Standl.) Skovsted	**G. *klotzschianum* Anders.	***G. *thurberi* Tod.
**G. *armourianum* Kearney	**G. *stocksii* M. Mast.	***G. sp. (Florida wild)
**G. *davidsonii* Kell.		

III. Other Malvaceae

Althaea rosea Cav.	*H. militaris* Cav.	*Malva parviflora
Hibiscus esculentus L.	*H. rosa-sinensis* L.	

Grasses Inoculated with Aecia from Cotton

***Bouteloua aristidoides* (H.B.K.) Griseb.	*M. rigens* (Benth.) Hitchc.
***B. barbata* Lab.	*M. wrightii* Vasey
**B. curtipendula* (Michx.) Torr.	*Sporobolus airoides* (Torr.) Torr.
***B. gracilis* (H.B.K.) Lag.	*S. asper* (Michx.) Kunth
***B. rothrockii* Vasey	*S. contractus* Hitchc.
Muhlenbergia arenacea (Buckl.) Hitchc.	*S. cryptandrus* (Torr.) A. Gray
M. monticola Buckl.	*S. flexuosus* (Thurb.) Rydb.
M. porteri Scribn.	*S. giganteus* Nash
M. pungens Thurb.	*S. heterolepis* A. Gray
M. racemosa (Michx.) B. S. P.	*S. texanus* Vasey
M. repens (Presl) Hitchc.	*S. wrightii* Munro

*** = Susceptible
** = Mildly susceptible
* = Resistant

It is of interest to note that all of the Old World cottons included in the test were either resistant or mildly susceptible, whereas most of the New World cottons were readily attacked. The Old World cottons have 13 chromosomes, and the cultivated New World cottons have 26. The question now arises, is there a relation between genetic make-up of the plant and susceptibility to the rust fungus? If we examine the table of plants tested we shall see that several American wild cottons were included, some of them having 13 chromosomes, others 26. The 26-chromosome group of cottons, both wild and cultivated, was susceptible without exception, while the 13-chromosome group was only mildly susceptible, with the exception of *G. thurberi*. This species was one of the most susceptible of the plants tested, based upon the number of pycnial clusters formed. Leaf texture and size undoubtedly could play an important role in an experiment of this nature.

It seems reasonable to believe that some of the species considered here as mildly susceptible might, under more favorable conditions, appear quite susceptible, and, conversely, some species, apparently rather susceptible under the conditions of the experiment might seem resistant under different conditions. Considering the results obtained with cotton there would appear to be little if any correlation between plant type or growth habits and susceptibility. There seems, however, to be some connection between the genetic make-up of the plant and degree of susceptibility.

INCIDENCE AND DAMAGE TO THE COTTON CROP

Ordinarily, the rust fungus attacks the leaves of cotton and may cause moderate shedding without seriously impairing the plants. If, however, there occurs a period of frequent rains accompanied by high relative humidity during late summer or early fall, the infection may become so severe that most of the leaves and many of the bolls are shed. An infection of such severity occurred in 1940 at Hidden Valley, Arizona.

The damage caused by a severe rust epidemic is difficult to estimate in terms of dollars or bales of cotton lost. It is apparent, however, that the cotton plants are weakened by the defoliation, and many bolls, not actually killed by the fungus, are left in condition to become easy prey to some of the boll-rotting organisms. Brown and Streets,[3] from observations made in 1930 in the Santa Cruz Valley, south of Tucson, Arizona, estimated loss of cotton yields as high as 75 per cent. The writers have observed fields in which the infection reached 100 per cent, and where more than half of the effective leaf surface of the plants was destroyed or impaired by the fungus. In such fields the loss in yield undoubtedly is heavy.

It is indicated from these studies that the telial stage of the rust occurs on certain species of *Bouteloua*, which, under ordinary desert conditions, are small and grow only during the rainy reason in summer or fall. In cotton fields where water is supplied by irrigation the same grasses will grow all summer and attain a size many times that of desert-grown specimens. A

[3] Brown, J. G., and R. B. Streets. Diseases of Field Crops in Arizona. University of Arizona Bull. **148**: 85–228. 1934.

comparison of *Bouteloua* plants grown on desert land adjacent to cotton and in a cultivated field is shown in figure 1, A and B. Not only is there a great difference in size of plants in irrigated and nonirrigated areas, but, also, in the amount of inoculum produced.

Since all species of *Bouteloua* commonly present in the irrigated Southwest are susceptible to the rust, there is a good chance of an abundance of telial material being present to infect cotton planted in any newly cultivated area. A greater amount of inoculum, however, is produced in the cotton fields where the grass is permitted to grow all summer. This is particularly true in fields where the cotton has been rattooned or "stubbed" and where clean culture is difficult to maintain. Prevention and removal of the grasses by clean cultural practices within the fields and along the ditch banks and fences should be beneficial as a control measure.

SUMMARY

The fungus causing the rust of cotton in the Southwestern States differs in at least one taxonomic character from the rust species heretofore described on *Bouteloua*. Within its urediospores 3 equatorial pores occur instead of several scattered ones, commonly present in other Bouteloua rusts. The name *Puccinia stakmanii* is proposed to designate this form of rust as a new species.

In a preliminary survey of the host range by greenhouse infection methods the following varieties and species were exposed to germinating telia: 48 cultivated cotton varieties representing 4 species, wild cottons representing 10 species, and other malvaceous plants representing 5 species. All cultivated cottons represented in *Gossypium hirsutum*, *G. barbadense*, and *G. hopi* were classed as susceptible; of the 3 varieties represented in *G. arboreum* 2 were resistant and 1 mildly susceptible; and of the 10 wild cotton species 8 were mildly susceptible and 2 susceptible; the other 5 malvaceous species were classed as resistant.

Twenty-two species of grasses representing 3 genera were inoculated with aecial material from infected cotton. From the results these were classed as follows: 4 of the 5 species of *Bouteloua* tested were susceptible and 1 mildly susceptible; the 8 species of *Muhlenbergia* and 9 species of *Sporobolus* inoculated were resistant.

The incidence and severity of rust infection on cultivated cotton are dependent on conditions of summer rainfall and humidity and on the amount of inoculum on the alternate host plants in the vicinity.

The Bouteloua grasses that develop within or on the margins of cotton fields commonly grow much larger and produce more infective telial material than desert-grown specimens, which are dependent on rainfall; hence, it is indicated that the practice of clean culture, including marginal areas, would be of value in control of the disease.

DIVISION OF COTTON AND OTHER FIBER CROPS AND
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DIPLODIA BLIGHT IN CONIFEROUS SEEDBEDS[1]

CHARLES M. SLAGG[2] AND ERNEST WRIGHT[3]

(Accepted for publication September 17, 1942)

While examining seedlings in a government nursery at Manhattan, Kansas, in August, 1941, the writers noted that first-year seedbeds of Douglas fir (*Pseudotsuga taxifolia* (Poir.) Britt.), Austrian pine (*Pinus nigra* Arnold), ponderosa pine (*P. ponderosa* Laws.), and piñon pine (*P. edulis* Engelm.) showed a number of dead and dying seedlings. The dark fruiting bodies of what appeared to be the causal fungus were plentiful on the dried central needles of the affected plants. Seedbeds of loblolly pine (*P. taeda* L.), slash pine (*P. caribaea* Morelet), and several small plantings of ponderosa pine from a California seed source were not affected.

This blight at first seemed to be similar to Phomopsis blight, which was under observation and treatment on adjoining eastern red-cedar seedbeds. Microscopic examinations on August 26 disclosed complete absence of *Phomopsis* and the presence of a single species of *Diplodia*. During the succeeding weeks the disease assumed serious proportions, and, by September 20, approximately 50 per cent of the seedlings of Douglas fir and Austrian pine were either diseased or dead. Injury to ponderosa and piñon pines was not so severe.

On September 25, an inspection was made of 3-year-old plantings of Austrian and Scotch pine (*P. sylvestris* L.) and of 5-year-old plantings of ponderosa and jack pine (*P. banksiana* Lamb.). A number of dead trees of Austrian and Scotch pines were found bearing the pycnidia and spores of the same *Diplodia* species found on the first-year seedlings. No first-year seedlings of Scotch pine were grown at the nursery in 1941, but infection of 3-year-old plantings was severe.

On October 9, a 50-year-old Austrian pine on the campus of Kansas State College at Manhattan was examined. About 50 per cent of the needles on the tree were dead and brown, and probably a much larger number had already fallen.

Numerous dark fruiting bodies were found on the basal portions of dead needles. Microscopic examination of the fruiting bodies disclosed the same species of *Diplodia* as that present at the government nursery 5 miles distant.

During the fall and winter of 1941–42 the fungus has been repeatedly found on mature trees of pitch (*P. rigida* Mill.), Table-Mountain (*P. pungens* Michx.), Austrian, Scotch, and ponderosa pines growing on the campus of Kansas State College. The most noticeable effect on these trees is a tip-

[1] Cooperative paper with the Division of Forest Pathology, Bureau of Plant Industry, U. S. Department of Agriculture, and Kansas State College, Department of Botany and Plant Pathology, Kansas Agricultural Experiment Station, contribution No. 425.

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blight and dieback of the foliage. In the trees examined this blight first appeared in the youngest apical needle clusters, later progressing back along the stem until the entire shoot sometimes became involved.

The youngest apical needle clusters first formed the typical fruiting bodies of the fungus. During the autumn months, many dead shoots showed pycnidia only on these apical needles. Later, pycnidia were found on older needles, on the bark, and on the scales of the cones.

The fungus causing this dieback of mature trees and death of young seedlings is very similar to that discussed previously on conifers by various workers (3, 5, 7, 9, 10) as a *Sphaeropsis*, by others (1, 2, 6, 8) as a *Diplodia*, and by Curtis (4) as *Botryodiplodia*. In microscopic examinations of naturally infected specimens at Manhattan, from 0 to 87 per cent of septate pycnospores were observed in different mounts. It was noted that the septate spores were darker, and wider in proportion to their length, than the nonseptate spores. One hundred unicellular spores averaged 13.0×35.3 μ,

TABLE 1.—*Septation of Diplodia pinea as influenced by location of pycnidia on Scotch pine (Pinus sylvestris)*

Location of pycnidia	Number of spores examined	Number septate	Number nonseptate	Percentage septate	Percentage pluriseptate
Long central needle	1817	5	1812	0.27	0.0
Short apical needle	400	21	379	5.3	0.3
Sheath at base of apical needle	300	153	147	51.0	1.0
On bark of twig	200	132	68	66.0	1.5
On scale of cone on same branch	281	243	38	86.5	2.5

while 100 septate spores averaged 14.65×32.1 μ. In crushed material the septate spores settled to the lower levels of water mounts and many were seen broken squarely across laterally, indicating the presence of a septum even though it might not be visible. Although there were wide variations in different pycnidia, about 25 per cent of the pycnospores observed were septate. The highest proportions of septate spores were found in mature overwintered pycnidia from large trees collected in March, 1942. Pluriseptate (usually 3-septate) spores were also fairly common in this material. Since fully ripened pycnidia always contained a higher proportion of septate spores than younger fruiting bodies, it seemed logical to assume that the bicellular spore was the mature form, and the fungus was identified as *Diplodia pinea* (Desm.) Kickx.

The causes for variation in septation of the pycnospores of *Diplodia pinea* are unknown. In the seedbeds, pycnidia on dead seedlings of Douglas fir produced only an occasional septate spore, while septation was abundant in pycnospores from adjacent similarly diseased seedlings of Austrian pine. Septation of pycnospores was always more pronounced in pycnidia formed near the bases of the pine needles than in pycnidia on other parts of the

needle. Table 1 shows the variation in septation of spores from pycnidia formed in different parts of a dead branch from a mature Scotch pine examined March 23, 1942.

Single-spore cultures of the fungus were readily secured from typical fruiting bodies on needles of first-year seedlings of Austrian pine. Three 1-foot-square blocks of uninfected Austrian pine seedlings, carefully removed with soil and roots undisturbed, were brought from a government nursery at Hutchinson to Manhattan, Kansas. A 15-day quarantine period was used to establish the absence of the disease and, on October 17, two of the three blocks of seedlings were inoculated and one was left as an uninoculated control. After inoculation all three lots were placed in a large damp chamber and left there for 72 hours. Upon removal they were placed on a greenhouse bench and examined daily.

Inoculation was accomplished in one block of seedlings by placing infected sporulating material from the nursery among the young plants. For some reason no infection resulted in this case. The other block of seedlings was inoculated with bits of young, vigorous mycelium from agar cultures placed on the uninjured growing points of all the plants in a section 6 inches square in the center of the flat. The mycelium rapidly invaded the tissues of the apical-needle cluster wherever applied and these apical needle clusters became discolored the fourth day after inoculation. By the fifth day, infection was apparent. On the tenth day the upper half of all inoculated seedlings was slate-colored and nearly dead. That portion of the block of seedlings that had been inoculated was smaller and the discoloration was marked as compared to the noninoculated seedlings in the same block, and also as compared to the control block, which remained vigorous and uninfected. Fifteen days after inoculation, a number of dark fruiting bodies were seen on the dead needles of inoculated seedlings. One such fruiting body was sectioned and examined under the microscope. It was a typical young pycnidium of *Diplodia pinea*. Thirty days after inoculation, all infected seedlings were dead.

The seedbeds had been sown approximately 5 months at the time the epiphytotic first became apparent. The Austrian pine seedlings that became diseased in the nursery and those used for inoculation purposes in the greenhouse were of substantially the same age and size, although grown in different nurseries, and had not yet completed development of woody tissues. At this stage of growth, infection rapidly became systemic and death of infected seedlings often occurred within a few days. It is important to note that infection in the cases here reported appeared to start first in the uppermost or youngest parts of the seedlings, also in the young centers of the needle clusters in the infected mature trees examined. In this respect the attack was quite different from that reported by Crandall (3) in his description of a root and collar disease of pine seedlings caused by *Sphaeropsis ellisii*.

A system of overhead watering in use at the nursery kept the seedbeds wet for a large part of the time. This fact, coupled with the splashing of

falling water, probably created favorable conditions for the spread of Diplodia infection after it became established in the beds.

There seems little doubt that this fungus has been parasitic upon various pines at Manhattan, Kansas, for many years. As far as the writers are aware, however, this is the first report of *Diplodia pinea* as a serious parasite of first-year seedlings.

SUMMARY

First-year seedlings of *Pinus nigra*, *P. edulis*, *P. ponderosa*, and *Pseudotsuga taxifolia* in a government nursery at Manhattan, Kansas, were severely blighted by a fungus identified as *Diplodia pinea* (Desm.) Kickx.

Uninjured seedlings of *Pinus nigra* were completely killed in 30 days by mycelial inoculations with a single-spore culture of *Diplodia pinea*. Typical pycnidia were formed on these dead seedlings 15 days after inoculation.

Diplodia pinea has been found on needles, needle bases, bark, and cone scales of "dieback" branches of mature trees of *Pinus nigra*, *P. ponderosa*, *P. pungens*, *P. rigida*, and *P. sylvestris* on the campus of Kansas State College at Manhattan, Kansas.

Septation of pycnospores of *Diplodia pinea* varied widely on different hosts and also varied on different plant parts.

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CONVEX GUM, A NEW DISEASE OF CITRUS IN CHINA

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(Accepted for publication September 10, 1942)

In the fall of 1941, a citrus-disease survey was made in Fukien Province, China. In an orange nursery at Kushanchow, Foochow, twig-blighting of a great majority of the nursery trees was strikingly apparent. These trees were about 4 years of age. When closely observed, the bark of the blighted twigs was seen to have many swellings with gum underneath, and, later, when the gum broke through, there were formed open irregular lesions, some of which girdled the twig in one or more places. In the open, broken lesions could be seen some dried gum. In an orchard at Chongha village, about 10 miles from Foochow City, a young tree was observed to have numerous swellings or convex areas on the bark of the trunk and limbs, but still lacked the later open lesions. When a convex area was cut open, a large quantity of gum was found in a pocket within the wood tissue. The disease was at once suspected to be the same as the more advanced destructive malady previously found on the orange nursery trees at Kushanchow. This conjecture was later confirmed. Observations were made of other orchards in the vicinity of Foochow City. Almost without exception, wherever orange trees were grown, the disease occurred.

PLANTS AFFECTED

In Foochow, only sweet orange (*Citrus sinensis*, variety, Kushanchow Kan) was found affected, Foochow tangerine (*C. nobilis*) and Ponkan (*C. nobilis*) being free from the disease. The orange trees were commonly affected at a young stage. Only 2 older trees, about 30 years of age, were found to be affected.

SYMPTOMS

The early symptoms of the disease were bark swelling and gum formation, which have suggested the name "convex gum," in contrast to the concave gum disease occurring in California, U. S. A. (2). There appear to be two types of the disease, so far as the symptom complex is concerned.

Type 1

This type was by far the more common and the more serious of the two. Large, smooth, and somewhat round bark swellings appeared on the trunk, limbs, and twigs of the trees. The swellings were often numerous, and generally larger on the trunk than on the twigs, averaging about 2.5 cm. in diameter.

When one of the swellings was cut into, a large quantity of brownish, semiliquid-to-cheesy gum was found in a large flattened pocket in the wood, 1 to 5 mm. beneath the cambium layer. The gum extended some distance beyond the elevated area. The cambium, however, appeared unaffected.

No alternate layers of gum formation were apparent, as in the case of the concave gum disease (2).

After a large quantity of gum had accumulated in the pocket, it broke through the bark and formed a cankerlike lesion, which appeared much like the injury done by the larva of a twig borer (Fig. 1). Two or more such lesions often coalesced. When they occurred on the twig, the latter usually was girdled and blighted. With lesions on older trees, however, callusing and healing-over generally took place, and no serious damage to the tree was noticeable.

The foliage of the affected trees appeared normal, except on the young trees with blighted twigs, in which case yellowing occurred. Symptoms on leaves, characteristic of psorosis (1), were not found. Such symptoms may possibly appear on the young leaves, however, with the coming of the grow-

FIG. 1. A twig of *Citrus sinensis* affected with convex gum disease (type 1), showing bark swellings and cankerlike lesions.

ing season, as the disease is regarded to be a type of psorosis (see discussion under "Etiology").

Type 2

This type was less common than type 1 and apparently caused no serious damage to the tree. Bark swellings on the trunk, limbs, and twigs of the trees were smaller than those of type 1, averaging about 1 cm. in diameter. The bark, when cut into, was found impregnated with gum, which appeared as numerous small, dark-brown spots.

ETIOLOGY

While the bark swellings had escaped the notice of all the growers, the irregular, open lesions and the twig blighting had been seen and erroneously ascribed to an unknown insect injury.

Inasmuch as the wood and bark tissue covering the gum pocket were uninjured and appeared normal, indicating no possible path for the invasion by an organism, and in the light of the findings of Fawcett (1, 4) with respect to the etiology of psorosis, it is believed that the present disease is caused by a virus, possibly a strain of the psorosis virus. It is suspected that the disease may be in some way related to scaly bark, which is very common on the tangerine orange in both the Foochow and the Chiangchow districts of Fukien Province. The possibility that the trouble may be due to a minor-element deficiency should also be considered. Further investigations will be made as soon as conditions permit.

EPIPHYTOLOGY

The disease is believed to be seed-transmitted; an assumption borne out by the fact that no trees propagated by the Chinese air-layering method, with the propagating limbs taken from healthy mother trees, have been found affected, while the diseased trees were always seedling trees.[1]

Evidence of the effect of phenological factors on the severity of the disease is not available. Observations so far made seem to indicate that convex gum may be aggravated by the lack of fertilizer, which supposedly weakens the tree.

ECONOMIC IMPORTANCE

In the nurseries and young orchards, affected trees under the age of 5 years were either dying or badly stunted, while the older diseased trees might appear normal. The percentage of trees affected was generally high. In one nursery the incidence was 100 per cent, and the majority of the trees were dying. Counts were made of affected trees in several orchards in Foochow. The results are presented in table 1.

TABLE 1.—*The severity of convex gum of citrus in several orchards in Foochow*

Orchard No.	Age of tree	Trees examined	Trees affected	Trees affected
	Years	*Number*	*Number*	*Per cent*
1	4	24	24	100
2	9	31	11	35
3	9	10	8	80
4	7	14	6	43
5	7	25	16	64

From this table it may be seen that the percentage of infection ranged from 35 to 100. The average percentage was about 64. Damage resulting from the disease may not be limited to the killing and stunting of the young trees. Affected trees that have temporarily recovered and appear normal may deteriorate sooner than the healthy trees, as is the case with psorosis-affected trees in the United States. It is obvious that the disease inflicts heavy losses to both the nursery men and the growers.

CONTROL

Since the disease appears to be seed-transmitted, it is suggested that mother trees be selected and placed under observation for 2 to 3 years and, if found free from the disease, be registered as certified trees for propagation, as is being done for the control of psorosis in California (3). Remedial measures are suggested by the experience of a grower at Kushanchow. A seriously affected tree, about 30 years old, recovered after the excision of affected tissue and application to the soil of a generous quantity of fertilizer. The lesions had all healed over, and the tree had regained a normal, healthy appearance. Such a method is in accord with what has sometimes been

[1] The great majority of oranges in Foochow are propagated by seedling trees.

employed by orange growers in California for the treatment of slight or medium cases of concave gum (2).

SUMMARY

A new citrus disease, called "convex gum," has been found in Southern China. The disease is characterized by bark swelling and gum formation on the trunk, limbs, and twigs, and it appears to be of two types. In type 1 the bark swelling is larger than in type 2, and a large quantity of gum is produced in a pocket in the wood tissue, 1 to 5 mm. underneath the cambium layer. The gum may break through the bark and form cankerlike lesions, which may coalesce, later girdling and killing the twigs. Young trees may be killed or badly stunted. In type 2, with smaller swellings, gum is formed in the bark and shows as small brown flecks. The disease is believed to be caused by a virus, probably related to the one causing citrus psorosis, or scaly bark.

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THE EFFECT OF SOIL AND CHEMICAL MIXTURES ON THE GROWTH OF FUSARIUM OXYSPORUM CUBENSE[1]

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The rate of growth of *Fusarium oxysporum cubense* has been recorded in several soil types.[2] Observations have been made on the highest non-toxic percentage and the lowest toxic percentage of chemical and soil-culture mixtures.[3] The work here reported has been an effort to find out the ability of chemicals to prevent the growth of the fungus in the soil.

Air-dried clay soil was used in the experiment. The moisture was determined, and the percentages given are those of the chemical ingredient and

TABLE 1.—*Chemicals that have not been observed to influence the growth of Fusarium oxysporum cubense in 1 per cent soil mixtures*

Aluminum sulphate	Citric acid	Potassium chromic sulphate
Ammonium chloride	Cobaltous nitrate	Potassium permanganate
Ammonium chromic sulphate	Cupric sulphate	Potassium sodium tartrate
Ammonium molybdate	Gas oil	Potassium sulphate
Ammonium nitrate	Hydrate line	Sodium carbonate
Ammonium sulphate	Kerosene oil	Sodium carbonate, acid
Antimonic acid	Lead arsenate	Sodium chloride
Barium bromide	Lead oxalate	Sodium hydroxide
Barium carbonate	Lead oxide, mono-	Sodium nitrate
Barium chloride	Lead oxide, red	Sodium nitrite
Barium nitrate	Magnesium chloride	Sodium tetrasilicate
Barium oxide	Manganous sulphate	Stannous chloride
Barium peroxide	Mercuric sulphide	Stannic oxide
Benzidine	Oxalic acid	Strontium carbonate
Bismuth oxycarbonate	Potassium aluminum sulphate	Strontium nitrate
Bismuth oxynitrate	Potassium antimony tartrate	Sugar
Calcium chloride	Potassium bromide	Zinc oxide
Calcium fluoride	Potassium chloride	Zinc sulphate
Calcium oxalate		

of the soil dried at 100° C. until a constant weight was obtained. The chemical was added with water up to 3 ml. to test tubes containing 10 g. of soil. The tubes were autoclaved and planted with *Fusarium oxysporum cubense*. The growth of the fungus was measured 7 days and 14 days, respectively, after planting.

There were 21 chemicals that inhibited the growth of the fungus in concentrations of 1 part per 100 or less (Table 2). Of the inhibiting chemicals there were 9 that prevented the growth at 1 part per 100 only, 1 chemical at 1 part per 1000, 8 chemicals at 1 part per 10,000, and 3 chemicals at 1 part per 100,000. Of the chemicals under observation 16 decreased the rate of growth of the organism but did not prevent the growth at 1 part per 100

[1] Acknowledgment is due the Jamaica Banana Producers' Association for support of this research.

[2] Meredith, C. H. The growth of *Fusarium oxysporum cubense* in the soil. Phytopath. 31: 91–93. 1941.

[3] Meredith, C. H. The effect of chemicals on *Fusarium oxysporum cubense* growing in the soil. Phytopath. 32: 182–184. 1942.

concentration. Copper oxalate, ferric sulphate, hydrochloric acid, lead acetate, magnesium sulphate, nickel sulphate, nitric acid, potassium bromide,

TABLE 2.—*The penetration of Fusarium oxysporum cubense in chemical and soil mixtures*

Chemical	No. of days	One part per 100	One part per 1,000	One part per 10,000	One part per 100,000	One part per 1,000,000	Check	Check
		cm.	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*	*cm.*
35. Acetic acid	7	.....	.....	1.6	1.4	1.5	1.9	1.6
	14	.....	0.1	3.4	3.6	3.2	3.1	3.0
70. Borax	7	.....	1.2	1.5	1.2	1.6	1.5	1.6
	14	.....	2.5	2.5	2.3	2.7	2.3	2.2
15. Boric acid	7	.....	0.5	1.1	0.9	1.6	1.9	1.3
	14	.....	0.5	2.2	3.0	2.6	3.2	2.1
100. Cadminum sulphate	7	.....	1.1	1.5	1.5	1.9	1.5	1.8
	14	.....	2.3	3.6	3.0	7.5	3.3	3.7
76. Iodine	7	.....	.....	0.5	0.7	1.0	1.3	1.5
	14	.....	.....	0.5	0.8	3.7	2.4	3.2
87. Mercuric ammonium chloride	7	.....	.....	.....	0.5	1.2	1.5	1.6
	14	.....	.....	.....	0.5	2.5	3.5	3.5
89. Mercuric carbonate	7	.....	.....	.....	0.3	0.5	1.4	1.1
	14	.....	.....	.....	0.2	0.5	3.0	3.5
7. Mercuric chloride	7	.....	.....	.....	.....	0.7	1.0	1.8
	14	.....	.....	.....	.....	2.1	2.4	2.6
88. Mercuric iodide	7	.....	.....	.....	.....	0.6	1.3	1.4
	14	.....	.....	.....	.....	2.8	2.6	3.1
53. Mercuric oxide (red)	7	.....	.....	.....	0.1	1.0	1.3	1.5
	14	.....	.....	.....	0.1	1.8	3.0	3.3
54. Mercuric oxide (yellow)	7	.....	.....	.....	.....	0.2	1.9	1.2
	14	.....	.....	.....	.....	0.3	3.0	3.1
90. Mercuric sulphate	7	.....	.....	.....	0.8	1.5	1.8	1.6
	14	.....	.....	.....	.....	2.5	3.0	3.2
16. Mercurous chloride	7	.....	.....	.....	0.8	1.1	1.5	1.8
	14	.....	.....	.....	2.3	2.8	4.9	3.0
3. Mercury dust No. 1	7	.....	.....	.....	0.4	1.3	1.4	1.9
	14	.....	.....	.....	0.3	3.2	3.1	3.0
4. Mercury dust No. 2	7	.....	.....	.....	0.4	0.5	2.1	1.7
	14	.....	.....	.....	2.3	2.5	2.9	3.3
60. Mercury dust No. 3	7	.....	.....	.....	0.2	0.7	1.2	2.4
	14	.....	.....	.....	0.2	0.5	2.5	4.0
48. Paris green	7	.....	1.5	1.5	1.0	1.7	1.7	1.2
	14	.....	3.5	3.1	2.7	3.7	3.3	2.5
45. Phenolphthalein	7	.....	1.4	1.4	1.7	1.5	1.2	1.5
	14	.....	3.4	3.8	3.5	3.0	3.4	3.2
2. Potassium dichromate	7	.....	0.9	1.4	1.7	1.5	1.5	1.9
	14	.....	2.3	2.9	3.2	2.7	3.4	3.0
8. Silver nitrate	7	.....	0.2	1.5	1.5	1.4	1.3	1.3
	14	.....	0.2	2.2	2.6	2.0	2.6	1.7
42. Thymol	7	.....	1.2	1.0	1.2	1.0	1.1	1.4
	14		2.6	2.3	2.9	2.8	3.5	2.8

potassium chlorate, sulfanilamide, sulphur, sulphuric acid, and 4 commercial sprays decreased the growth. There were 8 phosphorus compounds used in this study. Calcium phosphate, di-sodium phosphate, sodium am-

monium phosphate, sodium biphosphate, sodium di-hydrogen phosphate, sodium phosphate, superphosphate, and tri-sodium phosphate gave greater growth in concentrations of 1 part per 100 and 1 part per 1000 than the soil without the phosphorus in the check tubes. In this experiment 55 chemicals were not observed to affect the growth of the Panama disease organism in a 1 per cent mixture (Table 1).

The mercury compounds were the most effective in preventing the growth of *Fusarium oxysporum cubense* in the soil. Of the 12 mercury compounds observed 11 were able to inhibit the growth of the organism in concentrations of less than 1 part per 10,000.

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THE COMPOSITION OF WHITE CLOVER LEAVES AS AFFECTED BY RUST AND BY SULPHUR[1]

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A previous communication[2] reported the influence of leaf rust (*Uromyces trifolia* (Hedw. f.) Lév.) and of sulphur, that was used to control the rust, in decreasing the carotene content of white clover (*Trifolium repens* L.). Analyses for other constituents indicate that sulphur and rust exert an influence on some of these constituents. As no further analyses can be made in the near future, the results, though preliminary, are reported.

The plants used were the same as in previous studies.[2] Comparative analyses of rusted and sulphur-dusted susceptible plants are given in table 1. Moisture is expressed on the fresh-weight basis, other constituents on the

TABLE 1.—*Comparative analyses of rusted and rust-free plants of white clover*

Constituent materials	Average of 7 susceptible clones			Average of 2 resistant clones		
	Dusted	Rusted	F value	Dusted	Not dusted	F value
	Per cent	*Per cent*		*Per cent*	*Per cent*	
Moisture	77.20	75.87	10.57[a]	79.76	80.01	0.17
Crude protein N	3.22	3.36	7.17[b]	3.59	3.87	26.41[c]
Ash	14.37	15.08	4.06	13.40	12.84	17.15[c]
Fat	1.88	2.37	55.23[a]	2.08	2.28	2.40
Fiber	13.79	13.49	2.35	12.58	11.98	29.42[c]
N-free extract	49.76	48.01	10.59[a]	49.28	48.54	1.69

[a] Exceeds 1% point of 7.72.
[b] Exceeds 5% point of 4.22.
[c] Exceeds 1% point of 13.74.

dry-weight basis. From the data it is obvious that rusted plants were higher in protein and fat and lower in moisture and nitrogen-free extract than were sulphured plants. Analyses of dusted and nondusted, rust-resistant plants indicate (Table 1) sulphur has increased the ash and fiber and decreased the protein.

It is assumed that sulphur dusting affected rust-susceptible and rust-resistant plants equally. Therefore, to evaluate properly the effect of rust on susceptible plants, the effect of sulphur on the sulphured plants with which they are compared should be taken into account. Since sulphur has decreased the protein, the observed effect of rust in causing an increase in protein cannot be verified. The ash content has been increased by the rust to a greater degree than the data indicate and the difference is probably of

[1] Contribution No. 40, of the U. S. Regional Pasture Research Laboratory, Division of Forage Crops and Diseases, Bureau of Plant Industry, U. S. Department of Agriculture, in cooperation with the Northeastern States.

[2] Sullivan, J. T., and S. J. P. Chilton. The effect of leaf rust on the carotene content of white clover. Phytopath. **31**: 554–557. 1941.

significance. The effects of sulphur on the fat and on the nitrogen-free extract, while not of statistical significance, are in such a direction as to bring into question the significance of the effects of rust on the susceptible plants.

Another approach to the problem of determining the effect of rust is to compare the composition of rusted with non-rusted leaves from the same plant. Such a comparison is not complicated by the effect of sulphur. Leaves from rusted plants were grouped by hand as heavily rusted, lightly rusted and non-rusted. Analyses of these samples are summarized in table 2. The differences found here between rusted and non-rusted leaves are greater than those illustrated in table 1, but the rusted samples described in table 1 were of all leaves taken from rusted plants and not all leaves of such plants were rusted.

The rusted leaves are higher in ash, fat, fiber, and nitrogen-free extract and lower in moisture and protein than non-rusted leaves of the same plant (Table 2). All differences are significant. Though only fully developed

TABLE 2.—*Comparative analyses of leaves from same plant (average of 9 plants)*

Constituent materials	Heavily rusted leaves	Lightly rusted leaves	Non-rusted leaves	F value
	Per cent	*Per cent*	*Per cent*	
Moisture	70.11	72.74	76.23	85.89[a]
Crude protein N	3.21	3.47	4.03	167.63[a]
Ash	15.28	14.38	14.10	7.74[a]
Fat	2.56	2.21	1.99	38.44[a]
Fiber	13.61	12.75	12.49	32.35[a]
N-free extract	48.54	48.96	46.24	18.19[a]

[a] Exceeds 1% point of 6.23.

leaves were used, the composition of the non-rusted leaves as compared with the rusted is similar to that of younger as compared with older leaves. While more younger leaves may have been included in the non-rusted group, the differences in composition found are not believed wholly attributable to age. Ash content, the only constituent definitely shown increased by rust, serves as a criterion. The difference in ash content between heavily rusted and non-rusted leaves are what would be expected from the effects of rust alone. In another experiment leaves from the older halves of stolons of 3 rust-free clones averaged 16.3 per cent more ash than did leaves from the younger halves of the same stolons. If manual separation of rusted and non-rusted leaves placed a greater proportion of young leaves in the rust-free class the differences in ash caused by the two factors of age and rust should have been greater than that found.

It is concluded that both rust and sulphur have affected the composition of white clover plants and that sulphured plants cannot be used as controls in determining the effects of rust on certain chemical constituents of the plant.

PHYTOPATHOLOGICAL NOTES

The Antagonism of Actinomyces to Fusarium oxysporum cubense.[1]—A species of *Actinomyces* has been isolated that will dissolve the mycelium of *Fusarium oxysporum cubense.* The culture was collected from a compost heap made by Clifford L. Clemetson at Frontier, Port Maria, P. O., Jamaica. The agent that produced the lysis diffused through agar and checked the growth of the fungus. When spores of each organism were mixed together in a Petri dish of 2 per cent soil-extract agar the fusarium apparently developed for two days in a normal manner when compared with the check plates. The lysis was very evident on the fifth day, for sections of the mycelium had disappeared with small sections remaining. Some *Fusarium* chlamydospores were observed on the seventh day. In 9 days the fungus had disappeared and the *Actinomyces* sp. had made a normal growth similar to the check plates.—Clifford H. Meredith, Glenleigh Laboratory, Highgate, Jamaica, B.W.I.

Resistance in the Genus Nicotiana to Phytophthora parasitica Dastur var. nicotianae Tucker.—Thirteen *Nicotiana* species, including several strains and varieties of *N. tabacum,* have been tested, under greenhouse conditions, for resistance to black shank. All plants were transplanted to steam-sterilized soil previously inoculated with pure cultures of *Phytophthora;* all cultures having been isolated from infected tobacco and tested for pathogenicity. Data were taken as to total number of plants killed or partially infected; roots of surviving plants were examined for infection.

Under the severe conditions of these experiments no *Nicotiana* species or strains proved immune. Two varieties or strains of *N. tabacum,* Florida Rg and Tobacco Institute 150 (53–A), showed some resistance provided plants, set in inoculated soil, were approximately of size and age for field transplanting. When small seedlings of these varieties were set in inoculated soil nearly all plants were infected and a high percentage killed. Numerous observations of these varieties, grown in outside beds in naturally infested soil, give added support to data from these experiments, indicating that Rg and 150 (53–A) show but little, if any, resistance to black shank in the early seedling stage, under Puerto Rican conditions. Two commercial varieties, Virginia No. 9 and Utuado X No. 1, have shown some degree of resistance under field conditions based on commercial field observations and confirmed by data from a randomized field-plot experiment.[1] However, in these greenhouse experiments nearly all plants of Virginia No. 9 and Utuado X No. 1 were killed.

Three additional *Nicotiana* species, *N. repanda, N. rustica,* and *N. longiflora,* showed definite resistance to black shank. In *N. repanda* resistance

[1] Acknowledgment is due the Jamaica Banana Producers' Association for support in this research.

[1] Foster, H. H., M. García Fortuño and G. Irizarry Rubio. Notes on diseases, decays, and disorders of tobacco in Puerto Rico during the 1941–42 season. (Mimeographed) Pl. Dis. Rptr. 26: 247–253. 1942.

appeared to be located primarily in the roots. All infected plants observed showed active infection to be limited to the more succulent stems and leaves. In several plants when the disease reached the transition zone between stem and roots, infection was "corked" off. Plants of sufficient size and vigor to continue stem and leaf production appeared to recover completely. From the results of these experiments *N. repanda* might be of definite value in inter-species crosses with *N. tabacum*. It has been shown[2, 3] that *N. repanda* carries resistance to several other major tobacco diseases. Earlier, Tisdale[4] found that *Nicotiana rustica* was resistant to black shank but failed, in all attempts, to cross *N. rustica* with *N. tabacum*.

Numerous attempts were made, by the writer, to cross *Nicotiana repanda* with *N. tabacum*, using several different combinations. Germination of F_1 seed was obtained from a cross between (4–N *repanda*) × (2–N) *tabacum*. The (4–N) *repanda* plants were grown from colchicine-treated seed. All F_1 plants grew somewhat slowly, and, following transplanting, failed to recover and initiate new growth.—H. H. FOSTER, Department of Pathology and Genetics, Tobacco Institute of Puerto Rico, Rio Piedras, P. R.

Leaf Spot on Terminalia arjuna.—In February, 1937, while visiting the United States Plant Introduction Garden at Coconut Grove, Dade County, Florida, the writer observed a severe leaf spot on *Terminalia arjuna* Wight and Arn. growing in the garden. This conspicuous disease apparently has not been reported hitherto. It has continued abundant as shown by specimens received in subsequent years. These were collected by H. F. Loomis, who, with L. G. Polhamus, was present when the disease was discovered. The leaf spot appears on any part of the blade, and is circular to irregular and may be delimited by the veins. Usually, it is 2–8 mm. in diameter but is sometimes more extensive. Based on dry specimens, the color of the spot, above, is wood-brown, light brownish-drab, or pale-drab gray, and, below, mikado-brown to tawny-olive.[1] The necrotic area becomes dry, shrunken, and severed partly or entirely from the leaf as a whole. Severely infected leaves from which much of the dead tissue has fallen away present an extremely ragged or insect-eaten appearance. (Fig. 1, A–C.)

The disease seems to be of fungus origin. Pycnidia of the nature of *Phyllosticta* are present on the lesions, and among the organisms isolated is *Phomopsis* sp. (Fig. 1, D and E), as well as *Pestalotia*. The *Pestalotia* has been identified as *P. disseminata* Thüm. by E. T. Guba, who stated that this species, originally described on *Eucalyptus*, is widespread among members of the Myrtales.—ANNA E. JENKINS, Bureau of Plant Industry Station, Beltsville, Md.

[2] Clayton, E. E. Resistance to root-knot nematode in Nicotiana. (Abstract) Phytopath. 30: 708–709. 1940.

[3] Clayton, E. E., and H. H. Foster. Disease resistance in the genus Nicotiana. (Abstract) Phytopath. 30: 4. 1940.

[4] Tisdale, W. B. Development of cigar wrapper tobacco resistant to black shank. (*Phytophthora nicotiana* Breda de Haan) Florida Agr. Exp. Stat. Bull. 226, 1931.

[1] Color readings based on Ridgway, R. Color standards and color nomenclature. 43 pp. illus. Washington, D. C. 1912.

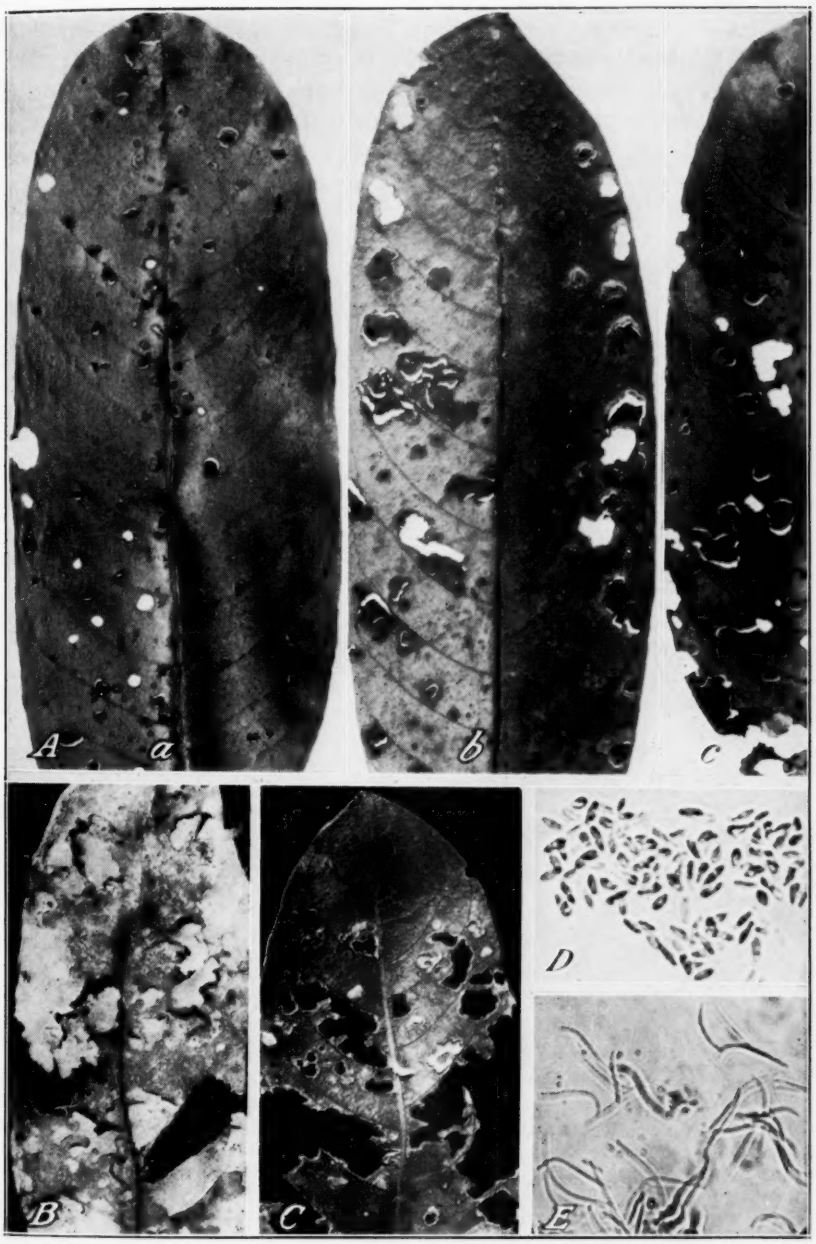

FIG. 1. A–C. Spotting of old leaves of *Terminalia arjuna*, U. S. Plant Introduction Garden, Coconut Grove, Fla. A, a and c, May, 1938, H. F. Loomis; A, b, February, 1937, L. G. Polhamus; B and C, January, 1939, H. F. Loomis. All ×1. D and E. *Phomopsis* sp., D, alpha spores; E, beta spores. ×500. All photographs by M. L. F. Foubert.

A Differential Medium for the Isolation of Phytomonas sepedonica.[1]— The study of the ring rot of potatoes frequently involves numerous routine isolations of the pathogen (*Phytomonas sepedonica*). This operation is relatively simple when the tubers employed are in the early stages of infection. If, however, the isolation is attempted from badly rotted tubers, sec-

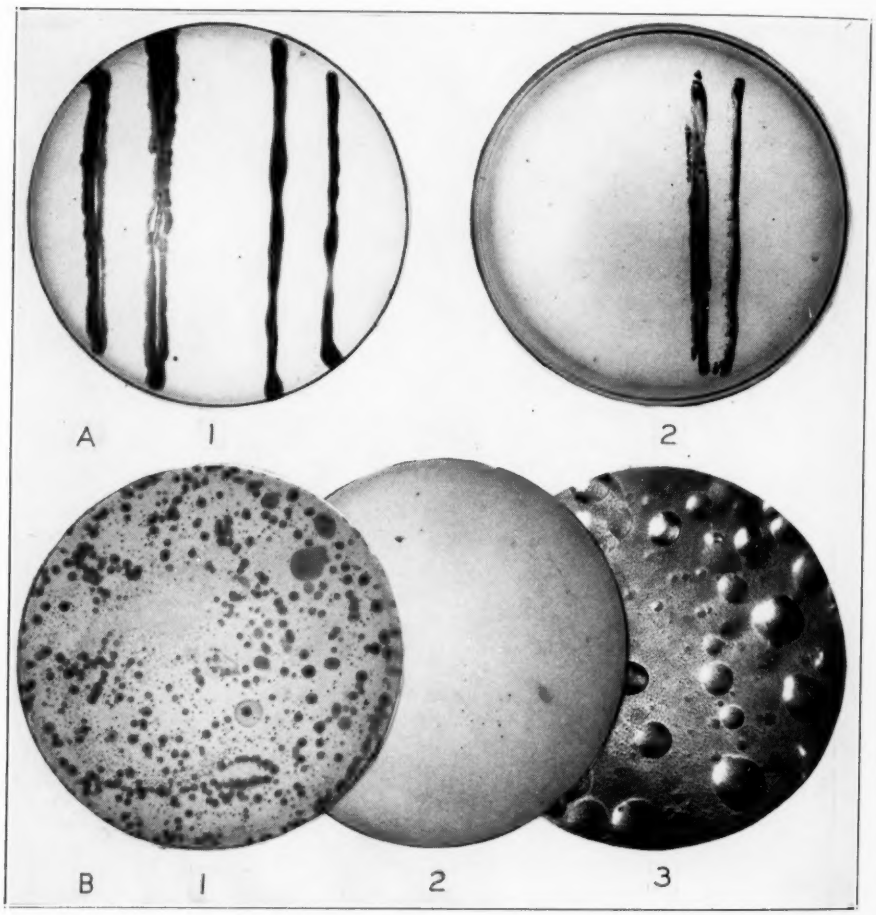

FIG. 1. Agar plate cultures showing effect of potassium dichromate on growth of soft-rot and ring-rot bacteria. A1. A control plate of Burkholder's agar streaked with a suspension of a pure culture of soft-rot bacteria (*Erwinia carotovora*) at left and *Phytomonas sepedonica* on right. A2. A plate of dichromate agar (1: 12,000) streaked with the two organisms. Note good growth of *P. sepedonica* and complete inhibition of *E. carotovora*. B1. A dilution plate of Burkholder's medium inoculated with mixture of soft-rot and ring-rot bacteria. Soft-rot colonies have overgrown the plate, completely obscuring any ring-rot colonies that might have developed. B2. A plate of dichromate agar (1: 12,000) inoculated in the same manner. The soft-rot bacteria were inhibited completely, while the ring-rot bacteria were present, although not visible here because of the small size of the colonies. B3. The colonies of *P. sepedonica* in the dichromate-agar plate shown in B2, photographed at 100× magnification.

[1] Published with the approval of the director of the West Virginia Agricultural Experiment Station as Scientific Paper No. 299.

ondary organisms of the soft-rot type (Gram-negative rods) usually crowd out the pathogen. A differential medium that largely overcomes this difficulty has been devised. It is based on Mallmann's[2] observation that potassium dichromate inhibits Gram-negative bacteria, while it permits the growth of Gram-positive species.

Burkholder's medium,[3] and a 1:1000 solution of C.P. potassium dichromate are the basic materials. These are prepared in separate flasks and sterilized. A heavy suspension of the yellowish exudate from the ring-rot lesion is made in sterile water. From this master suspension, loop dilutions are made to a series of duplicate plates. The liquefied agar, cooled to 50° C. is mixed with the calculated amounts of sterile 1:1000 potassium dichromate solution. Usually dilutions of 1:9000, 1:12,000, and 1:15,000 give satisfactory concentrations to accommodate the varying conditions incident to isolation. Approximately 10 ml. of the medium is poured over the bacterial suspension and thoroughly mixed. The cultures are incubated at 22° C. in a moist chamber. After 7 to 9 days, distinct pin-point colonies of the ring-rot bacteria appear in the agar. Isolation of these colonies is easily effected by the usual technique of "fishing," using a finely sharpened chromel wire needle for this purpose. The sharp differential action of this medium is shown in figure 1.—E. A. MARTEN, C. V. LOWTHER, and J. G. LEACH, Department of Plant Pathology and Bacteriology, West Virginia University, Morgantown, W. Va.

Leaf Blight of Corn.—Leaf blight of dent corn has been under observation in Ohio for the last 4 seasons. With the introduction and widespread use of corn hybrids it has become more important, especially in the southern half of the State. It is estimated that the loss resulting from leaf blight in southern Ohio in the last 4 years has exceeded that from any other disease. Work was initiated in 1939, in Ohio, to determine the major cause or causes of the disease. Many growers of corn hybrids were much concerned; the trouble was variously attributed to drought injury, poor soil conditions, and Stewart's disease or bacterial leaf blight.

During July, August, and September, 1939 more than 200 isolations were made from collections of diseased corn leaves from different regions in southern Ohio. Pathogenicity of the isolated organisms was tested. Bacterial isolates were hypodermically injected into stalks of 6- to 8-inch greenhouse-grown corn plants, while the isolated fungi were tested by spraying like plants with a spore suspension in water and then maintaining them 24 to 36 hours in a moist chamber. These experiments indicated two kinds of leaf blight in Ohio: bacterial, caused by *Phytomonas stewarti* (Sm.) Com. S. A. B., and Helminthosporium leaf blight caused by *Helminthosporium turcicum* Pass. The latter being the more prevalent.

[2] Mallmann, W. L. The selective bacteriostatic effect of slow oxidizing agents. Jour. Bact. 42: 295. 1941.

[3] Burkholder, W. H. The occurrence in the United States of the tuber ring rot and wilt of the potato. Amer. Potato Jour. 15: 243–245. 1938.

Symptoms characterizing the two blights differ distinctly and are usually readily distinguishable in the field. The bacterial lesions are spots of irregular shape, or streaks often extending almost the entire length of the leaf. The individual spots produced by *H. turcicum* are more or less elliptical, 1 to 4 cm. wide by 14 cm. or less long; often a brown to reddish margin, with zonation apparent in some spots. The center of the fungus lesions is often covered with a greenish-black growth of conidia and conidiophores. Coalescence of lesions may occur in both types of blight, and the leaf soon dies and becomes dry.

Preliminary tests of the reaction of inbred lines, single crosses, and double crosses of dent corn to *Helminthosporium turcicum* were made in the greenhouse. Plants of 24 inbred lines, 26 single crosses and 6 double crosses were sprayed with a water suspension of spores and then placed in a moist chamber for 24 to 36 hours. The results showed no seedling resistance in any of these lines or crosses.

The isolation and inoculation tests suggest that the fungus *Helminthosporium turcicum* induces most of the leaf blight in Ohio, a fact further established by many observations of experimental breeding plots, cooperative test plots, and farm fields made in August and September, 1940, 1941, and 1942. Marked differences in amount of infection also were then noted between the different inbreds and crosses grown side by side. Inbred lines KYS, Ia. L317, Ia. L289, Ohio 02 and Ohio 40B are some that are resistant to Helminthosporium blight, while Ia. 1224, Ill. A. U. S. 540, Wis. CC5 and Ohio 67 are very susceptible. Hybrids Ia. 939, U. S. 13 and Ohio L86 have been resistant, while Ind. 614, Ind. 608C, U. S. 44, and Ohio C14 are very susceptible in southern Ohio. In 1938 Ohio produced 316 acres of hybrid Indiana 614 seed. By 1942 there was only 11 acres, due chiefly to Helminthosporium leaf blight.

Although bacterial leaf blight has been present in many Ohio fields in the last four years, it has been observed causing serious losses in but few instances. Although present in many Ohio fields since 1939 it has been observed causing serious losses in but few instances.

Helminthosporium turcicum also has been isolated from Sudan-grass (*Sorghum vulgare* var. *sudanense* (Piper) Hitchc.) and Johnson-grass (*Sorghum halepense* (L.) Pers.) collected in southern Ohio.—C. W. ELLETT,[1] Department of Botany, The Ohio State University, Columbus, Ohio.

Influence of Plant Populations upon Incidence of Pineapple Yellow Spot.[1] —Recent studies on the influence of tomato plant populations and planting systems upon incidence and destructiveness of the curly-top disease,[2] add interest to data taken by the writer some years ago on yellow-spot of pine-

[1] Acknowledgment is made to Dr. C. C. Allison and Dr. W. G. Stover for helpful suggestions in the course of the work.

[1] Published with the approval of the Acting Director as Technical Paper No. 144 of the Pineapple Research Institute of Hawaii, University of Hawaii.

[2] Shapovalov, M., H. L. Blood, and R. M. Christiansen. Tomato plant populations in relation to curly-top control. (Abstract) Phytopath. 31: 864. 1941.

apple, *Ananas comosus* (L.) Merr. This disease is transmitted by *Thrips tabaci* Lind.,[3] and is caused by a virus probably identical with that of tomato spotted wilt.[4,5] Infection of pineapple plants results chiefly or exclusively from the feeding of thrips that have developed on more favorable hosts of both virus and vector. Pineapple plants are susceptible during early growth, soon after planting, and again during development of the fruit. Plants infected early die without fruiting; hence, this disease in fruiting plants represents infection after the inflorescence has begun to develop.

In a plantation experiment in which population density had been varied by 3 widths of spacing between plants in the rows of 4-row beds, the prev-

TABLE 1.—*Incidence of yellow-spot of pineapple fruits and crowns, per cent and per acre, related to 3 intervals of spacing of plants in the rows and the resulting numbers of plants per acre*

Replication	Infections per 100 plants			Infections per acre		
	12 in.	15 in.	18 in.	12 in.	15 in.	18 in.
	21,780	18,150	14,520	21,780	18,150	14,520
	Per cent	*Per cent*	*Per cent*	*No.*	*No.*	*No.*
1	3.0	4.8	5.5	653	871	799
2	3.5	4.3	5.3	762	780	770
3	3.4	4.6	4.6	740	835	668
4	3.3	.....	5.4	719	.....	784
Mean	3.3	4.6	5.2	718	829	755
Difference, per cent	.....	39.4	57.6	.....	15.5	5.2
F[a]	.....	.....	67.7[b]	.....	.....	0.94

[a] With 1 and 6 degrees of freedom in comparisons of 12 inch and 18 inch spacings, F = 5.99 for 5 per cent probability and F = 13.74 for 1 per cent.

[b] After angular transformation of percentages to degrees, the calculated F value is 72.5.

alence of yellow-spot infection was determined just prior to harvest. All beds consisted of 4 rows 17 inches apart, with the beds spaced 8 feet from center to center; but plants in the rows were spaced 12, 15, and 18 inches apart, resulting in populations of 21,780, 18,150, and 14,520 plants per acre, respectively, when the area occupied by field roads is not considered. Each spacing was represented by 4 replications of 4-bed plots 300 feet long, with plots and treatments arranged parallel in systematic rotation in a strip 384 feet wide. Fertilizer had been applied before planting at a uniform rate per unit area. Later applications were uniform per plant.

Counts were made of fruiting plants in each plot and of plants with fruits or crowns or both infected with yellow-spot. The data are presented

[3] Linford, M. B. Transmission of the pineapple yellow-spot virus by *Thrips tabaci*. Phytopath. 22: 301–324. 1932.

[4] Parris, G. K. Mechanical transmission of yellow-spot virus: evidence for identity with spotted-wilt virus. Phytopath. 30: 299–312. 1940.

[5] Sakimura, K. Evidence for the identity of the yellow-spot virus with the spotted-wilt virus: experiments with the vector, *Thrips tabaci*. Phytopath. 30: 281–299. 1940.

in table 1 on a percentage basis and as calculated numbers of infected plants per acre.

Consistency of the percentage of infection among plots of equal population density is sufficient to demonstrate the significance of differences between spacings. The 12- and 18-inch spacings are clearly distinct, with 57.6 per cent heavier infection in the latter. The unfortunately incomplete data from the intermediate spacing overlap somewhat those from the widest spacing, but indicate an intermediate percentage of infection.

Numbers of infections per acre, on the contrary, show no such significant influence of plant population. The apparent differences between means are small and may be wholly a result of chance. If they are real differences, however, they indicate slightly more infections per acre in the intermediate population, with the population extremes close together. Such differences might be attributable to differences in plant susceptibility induced by the different spacings, for spacing did modify growth. Data on fruits and crowns taken during harvest showed that fruit weight diminished as plant population increased. Time of ripening was influenced very little, as was also the apparent quality of the fruit. Crowns, however, were smallest in the closest planting, slightly larger in the most open planting, but still a little larger in the intermediate; and this may have influenced infection inasmuch as crown leaves are susceptible only while elongating and only in the immature zone at the base. There was nothing to suggest that differences in susceptibility were very great.

There had been no important source of vectors within this field. It is presumed, therefore, that thrips were carried in by the prevailing winds from a vacant field located several hundred yards from the nearest corner of this experiment—a field that during and for a time following blossoming of the experimental plants, had supported an abundant growth of weeds.

These data support the hypothesis that infective thrips, blown in from a distance, were scattered almost uniformly over the experimental planting, resulting in approximately equal numbers of infections per unit area but in percentages of infection that are inversely related to plant-population density. Plots with plants 18 inches apart, having only two thirds as many plants per unit area as plots with 12-inch spacing, would be expected to have 50 per cent more infections, a figure reasonably close to the observed value of 57.6 per cent. Although the intermediate spacing gave results not fitting quantitatively so well with expectations, it, too, agrees in showing a lower percentage of infection to accompany dense plant populations, and its departure from expectations is within limits of likely influences of plant susceptibility.—M. B. LINFORD, Pineapple Research Institute, Honolulu, Hawaii.

Thiosan (Tetramethyl Thiuramdisulfide) and Scurf Control of Sweet Potatoes.—Since an adequate supply of mercury for fungicidal purposes has become less certain than usual, a new interest in mercury substitutes for

sweet-potato seed and sprout-dip treatments has been aroused. In this connection considerable interest has been shown in Spergon (tetrachloro para benzoquinone). Elmer[1] reports obtaining good control of stem rot by the use of this material. Daines[2] found that Spergon offers only mild control of scurf, while Cook and Harter[3] found that this chemical was not effective for the control of black rot. From these reports it would appear that the use of Spergon on sweet potatoes will be somewhat limited.

During the growing season of 1942, several non-mercurial fungicides were compared with Semesan Bel as sprout dips for the control of scurf (*Monilochaetes infuscans*) and stem rot (*Fusarium* sp.), on the College Farm

TABLE 1.—*Results of sprout treatments for scurf control*

Treatment	Amount of control							
	Underground portion of stem			Fleshy roots				
	No. examined	Free from scurf	Scurf	Sweet potatoes examined	Free from scurf	Slight scurf	Medium scurf	Unsalable from scurf
		Per cent	*Per cent*	*No.*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
1. Semesan Bel, 1 lb. to 10 gal.	150	54.0	46.0	405	49.9	22.5	7.6	20.0
2. Semesan Bel, 1 lb. to 10 gal.—sprouts held 4 hr. after the dip treatment before planting[a]	150	70.0	30.0	536	66.6	14.4	6.7	12.3
3. Thiosan, 1 lb. to 7½ gal.	150	56.0	44.0	408	38.2	24.8	12.0	25.0
4. Thiosan, 1 lb. to 5 gal.	150	61.4	38.6	457	61.9	21.0	5.7	11.4
5. Spergon (wettable) 12 oz. to 1 gal.	150	34.0	66.0	404	23.2	22.3	14.9	39.6
6. Untreated check	150	6.0	94.0	362	8.0	16.3	14.1	61.6

[a] The sprouts in treatment 2 were wrapped in moist burlap and held for 4 hours before setting in the field. The plants in all other treatments were planted within 15 minutes after the treatment was made.

in New Brunswick. One-half of the Semesan Bel-treated sprouts were planted shortly after they were disinfected, whereas the remaining plants were held for 4 hours following the treatment before being planted. The soil in which the potatoes were grown was a sassafras loam. This soil being heavier than the ordinary sweet-potato soil, favors the development of scurf and renders injury from mercury less likely to occur than would be the case in the sandy loam soils of South Jersey. The sprouts used in this test were grown from nontreated potatoes that were badly affected with scurf.

[1] Elmer, O. H. 1942. Use of Spergon for sweet potato seed and sprout treatment. Pl. Dis. Reptr. **26**: 44–46.

[2] Daines, Robert H. 1942. Spergon (Chloranil) and scurf control of sweet potatoes. Pl. Dis. Rptr. **26**: 160.

[3] Cook, H. T., and L. L. Harter. 1942. Wettable Spergon not effective as a surface disinfectant of sweet potatoes used for seed. Pl. Dis. Rptr. **26**: 222.

Each treatment consisted of a row of 100 plants that was replicated 3 times. Moist soil and warm weather at time of planting favored the rapid establishment of the plants.

An examination of the underground portions of the plants one week after setting, revealed that the sprouts in the Semesan Bel treatments had lost the use of most of the rootlets that were present at setting time. However, new rootlets, as in the other treatments, had already appeared and the aboveground portions of the plants looked as good as those of any treatment. Although injury was present in both treatments where Semesan Bel was used, it was most prevalent in the treatment where the sprouts were held 4 hours after treating before being set in the field. In this treatment approximately 63 per cent of the plants showed browned areas on their stems. Where the plants were set within 15 minutes of the treatment, the browned areas were present on 22 per cent of the stems. The sprouts in all remaining treatments showed no evidence of root or stem injury from the chemical burning, since the stems were free from burned areas and the rootlets that were present at setting time were still functional.

Stem rot was present in only 5 per cent of the nontreated check plants, and although it was less abundant in all the treatments, the incidence of infection was not sufficiently great for the data on stem-rot control to be of much value.

At harvest time data were taken to record the presence or absence of scurf on the underground portions of the stems and on the sweet potatoes themselves. These data are given in the accompanying table.

In this experiment Semesan Bel and Thiosan (tetramethyl thiuramdisulfide) gave good scurf control. This was particularly true for the Semesan Bel-treated sprouts where planting was delayed, and for the 1 to 5 Thiosan treatment. The control provided by Spergon was only moderate, even at the high concentration used.

From the data presented here (Table 1) it would appear that Thiosan 1–5 offers good possibilities as a sweet-potato-sprout dip for scurf control. Under conditions of severe scurf this material was as effective as Semesan Bel. Although the conditions of the test did not favor sprout injury, the data on the injury that did occur justify optimism. One disadvantage with this material in its present state is in its physical properties. Because of its tendency to settle, unusually vigorous agitation of the dipping solution is required.

From the scurf and sprout-injury data obtained from sprouts planted shortly after a Semesan Bel treatment is made as compared with a delayed planting, it would appear that holding sprouts after the treatment increases the fungicidal efficiency of the treatment and also the likelihood of chemical injury.—ROBERT H. DAINES, Agricultural Experiment Station, New Brunswick, N. J.

REPORT OF THE ANNUAL MEETING OF THE COUNCIL OF THE AMERICAN PHYTOPATHOLOGICAL SOCIETY FOR THE YEAR 1942

Results of a questionnaire sent to members in 68 institutions and representing the opinion of approximately 300 members were predominately in favor of cancellation of the 34th annual meeting scheduled for New York, December 27–31, 1942. However, members were greatly in favor of a meeting of the old and new officers and councilmen in conjunction with a meeting of the War Committee of The American Phytopathological Society. Also, members voting were almost unanimously in favor of giving emergency authorization to the Council to make appointments, elect new members, and transact necessary business without immediate approval of the Society—such appointments and business decisions to be immediately effective, but subject to approval of the Society at the next general meeting—all appointments and business decisions to be published in PHYTOPATHOLOGY.

On the basis of this information a business meeting of the Council was held in connection with a meeting of the War Committee, February 12–14, 1943, in the Deshler-Wallick Hotel, Columbus, Ohio.

A conference on "reduced dosages of fungicides and insecticides," previously scheduled for the New York meeting, was held on February 14 with representatives from The American Phytopathological Society, the American Association of Economic Entomologists, and the Biometrics Section of the American Statistical Association participating.

OFFICERS, REPRESENTATIVES, AND COMMITTEES FOR 1943

Officers:

J. C. WALKER, President (1 yr.), University of Wisconsin, Madison, Wisconsin.
J. J. CHRISTENSEN, Vice-President (1 yr.), University Farm, St. Paul, Minnesota.
C. C. ALLISON, Secretary (3 yr. term expires 1944), The Ohio State University, Columbus, Ohio.
H. A. EDSON, Treasurer (3 yr. term expires 1943), Bureau of Plant Industry Station, Beltsville, Maryland.
H. B. HUMPHREY, Editor-in-Chief of PHYTOPATHOLOGY (3 yr. term expires 1945), Bureau of Plant Industry Station, Beltsville, Maryland.

Councilors:

J. G. LEACH (term expires 1944), University of West Virginia, Morgantown, West Virginia.
L. M. HUTCHINS (term expires 1943), Bureau of Plant Industry Station, Beltsville, Maryland.
H. A. RODENHISER (term expires 1943), Bureau of Plant Industry Station, Beltsville, Maryland.
O. C. BOYD (New England Division), Massachusetts State College, Amherst, Massachusetts.
G. A. HUBER (Pacific Division), Western Washington Experiment Station, Puyallup, Washington.
A. G. PLAKIDAS (Southern Division), Louisiana State University, University, Louisiana.

Representatives:

A.A.A.S. Council. L. M. HUTCHINS, J. G. LEACH.
Division of Biology and Agriculture, National Research Council. J. C. WALKER (3 yr. term expires June 30, 1946).
Tropical Research Foundation. ROBERT D. RANDS (5 yr. term expires 1945).
Board of Editors, American Journal of Botany. G. W. KEITT (3 yr. term expires 1943).
Union of American Biological Societies (and Biological Abstracts). C. W. BENNETT, DONALD FOLSOM, G. W. KEITT, L. M. MASSEY; H. B. HUMPHREY and C. C. ALLISON (ex officio). F. V. RAND, Chm.

Standing Committees:

Donations and Legacies. J. G. BROWN, N. J. GIDDINGS, E. C. STAKMAN, N. E. STEVENS, R. P. WHITE, Chm.

Extension Work and Relations. S. B. FENNE, R. J. HASKELL, G. W. KEITT, R. H. PORTER, OTTO REINKING, R. C. ROSE, D. R. SANDS, W. B. TISDALE, O. D. BURKE, Chm.

Investments. CHARLES BROOKS, MARVIN E. FOWLER, J. W. ROBERTS, H. A. EDSON, Chm.

Necrology. M. B. WAITE, A. G. JOHNSON, Chm.

Phytopathological Classics. H. H. WHETZEL, Mgr., H. B. HUMPHREY, Editor.

Public Relations. L. M. BLANK, O. C. BOYD, K. STARR CHESTER, J. J. CHRISTENSEN, C. T. GREGORY, J. H. JENSEN, FRANK MCWHORTER, A. G. NEWHALL, J. A. PINCKARD, LUTHER SHAW, G. H. STARR, C. E. YARWOOD, G. F. WEBER, Chm.

Recognition of Merit. C. R. ORTON, CHARLES CHUPP, J. G. LEACH, L. M. HUTCHINS, H. W. ANDERSON, Chm.

Regulatory Work and Foreign Plant Diseases. J. F. ADAMS, A. A. BITANCOURT, A. B. BUCHHOLZ, S. J. P. CHILTON, F. L. DRAYTON, M. R. HARRIS, W. A. MCCUBBIN, Chm.

Special Committees:

Coordination in Cereal and Vegetable Seed Treatment Research. C. H. ARNDT, H. T. COOK, F. J. GREANEY, C. M. HAENSELER, K. W. KREITLOW, L. D. LEACH, J. H. MCLAUGHLIN, G. L. MCNEW, P. P. PIRONE, H. A. RODENHISER, M. B. MOORE, Chm.

Fungus Nomenclature. C. M. TUCKER, D. S. WELCH, ERDMAN WEST, G. L. ZUNDEL, J. A. STEVENSON, Chm.

International Cooperation and Reorganization. C. W. BENNETT, J. J. CHRISTENSEN, CHARLES CHUPP, J. A. STEVENSON, J. C. WALKER, FREEMAN WEISS, W. J. ZAUMEYER, L. M. HUTCHINS, Chm.

Nomenclature and Classification of Plant Viruses. C. W. BENNETT, E. W. BODINE, EUBANKS CARSNER, F. O. HOLMES, JAMES JOHNSON, FREEMAN WEISS, H. H. MCKINNEY, Chm.

Publication of Monographs. H. S. FAWCETT, F. D. FROMME, L. R. HESLER, L. H. LEONIAN, T. F. MANNS, MAX GARDNER, Chm.

Standardization of Fungicidal Tests. J. G. HORSFALL, R. W. LEUKEL, J. W. ROBERTS, C. F. TAYLOR, H. W. THURSTON, J. D. WILSON, S. E. A. MCCALLAN, Chm.

Terminology (Nomenclature) of Immunology and Use of Technical Words. JESSIE I. WOOD, N. E. STEVENS, Chm.

War Committee. E. C. STAKMAN, J. G. LEACH, Acting Chm., R. P. WHITE (Executive Committee).

Temporarary Committees for 1942:

Auditing. R. D. RANDS, CARL HARTLEY, Chm.

Resolutions. N. E. STEVENS, W. G. STOVER, A. E. DIMOND, Chm.

REPORTS OF OFFICERS, REPRESENTATIVES, AND COMMITTEES FOR 1942

Report of the Secretary. On January 1, 1942, the membership of our Society totaled 1118. At the time of our Council Meeting, February 12, 1943, the membership was 1085. This makes a net loss of 33 members. During the period January 1, 1942, to February 12, 1943, 66 individuals applied for membership. By action of the Council, meeting at Columbus, Ohio, February 12, all applicants were elected to our Society.

Six former members have been reinstated, and the Society lost a total of 104 members: 28 by resignation, 4 by death, and 72 suspended for nonpayment of dues. Of the 72 suspended, 5 were from South America, 1 from Canada, and 29 from other foreign countries. Of the full membership, 155 are paid-up life members, and 1 is paying $10.00 a year toward life membership.

The Secretary here calls attention to the fact that suspended members may be reinstated by notifying the Secretary and paying dues for the current year. Former members should be advised of this and urged to seek reinstatement, if their professional work is directly related to plant diseases and their control.

The Clearing Agency of the Society was continued in 1942. There are 54 applications on hand—16 new ones in 1942, and 6 so far in 1943. Several applications were removed from the Agency because of suspension from the Society for nonpayment of dues. One hundred fifteen applications of 40 pathologists were sent to 21 employers, who requested applications. Three applicants reported they were hired by contact made through the Clearing Agency.

Report of the Treasurer. Statement of accounts for the year ending November 30, 1942.

Receipts:

Balance from 1941			$2569.47
Annual dues:			
1941	$ 34.50	($10.00, life)	
1942	2592.07	(10.00, life)	
1943	1674.75	(10.00, life)	
1944	1.00	$4302.32	
Donations from members for foreign subscriptions		20.00	
Balance from A. P. S. dinner in Dallas		21.75	
Index payments included in checks for dues		206.00	
Sales		2.20	
Excess illustrations		9.08	
Total receipts			4561.35
			$7130.82

Expenditures:

Member subscriptions transferred to PHYTOPATHOLOGY:			
1941	$ 23.50		
1942	3701.16	$3724.66	
Transferred to PHYTOPATHOLOGY for:			
30-Year Index	263.00		
Donations for foreign subscriptions	20.00		
Sales	2.20		
Excess illustrations	9.08	$ 294.28	
Secretarial work and expenses of office of Secretary		409.29	
Secretarial work for Treasurer		329.19	
Printing		189.72	
Stamps and envelopes		86.37	
Typewriter and supplies		86.73	
Entertainment, dinner in Dallas		25.00	
Checks returned by bank		19.75	
Miscellaneous: express, telegram, etc.		1.55	
Total expenditures			5166.54
Balance on hand			1964.28
			$7130.82

Sinking Fund. The Sinking Fund, the income from which is used for the support of PHYTOPATHOLOGY, has been obtained by deducting $5.00 from each life-sustaining membership installment. All life-sustaining members have paid in full except for one in Italy who, of course, will be unable to complete his payments for the present. The fund totaled $9661.00 at the close of 1941. During the year it increased to $9676.00 and is invested as follows:

First mortgage notes deposited with the McLachlen Banking Corporation for collection ($1000.00 at 6%, $500.00 at 5%)	$1500.00
Invested with the following building and loan associations:	
Arlington and Fairfax Bldg. and Loan, 4%	1000.00
Columbia Permanent Bldg. Association, 4%	500.00
District Bldg. and Loan Association, 4%	1500.00
National Permanent Bldg. Association, 4½%	2000.00
Northwestern Fed. Savings and Loan Association, 3½%	2000.00
Perpetual Bldg. Association, 4%	1000.00
Prudential Bldg. Association, 3½% (accrued interest, $8.87)	184.87
	9684.87
Less interest due PHYTOPATHOLOGY	8.87
	$9676.00

The Lyman Memorial Fund, obtained from voluntary contributions, now totals $3132.57. The whole amount is invested with the Brookland Building and Loan Association at 3½%. The account for 1942 follows:

Balance on hand, December 15, 1941	$3181.53
Dividends, Dec. 31, 1941, and June 30, 1942	112.02
Contributions from members	0.25
Sales of Erwin F. Smith Memoir	5.00
	3298.80
Accrued dividends transferred to PHYTOPATHOLOGY, Aug., 1942	166.23
	$3132.57

Report of the Business Manager of PHYTOPATHOLOGY. At the close of 1941 there were 584 nonmember subscribers, including 6 complimentary. In 1942 there were 21 cancellations and 186 suspensions for nonpayment, a loss of 207. As there were only 38 new or restored subscriptions, a net loss of 168 resulted. The domestic list remained the same, the number of Pan American subscribers showed a slight increase, but the loss of 78 in the European area and 89 in the Pacific war zone reduced our total list of nonmember subscribers to 416, the lowest since 1925. This loss of subscribers, however, has been partly offset by the purchase by the American Library Association of 45 sets of Volume 32 (1942) of PHYTOPATHOLOGY for future distribution to foreign addresses.

Statement of accounts for the year ending November 30, 1942.

Receipts:

Balance from 1941			$ 5903.33
Subscriptions:			
1941	$ 24.00		
1942	1993.91		
1943	323.75		
1944	5.50	$2347.16	
Member subscriptions:			
1941	23.50		
1942	3701.16	3724.66	
Sales of back numbers (including orders for current and back numbers reserved for American Library Association)		1032.53	
Advertising:			
1941	134.85		
1942	679.06	813.91	
30-Year Index		1013.03	
Interest on Sinking Fund			
First mortgages	85.00		
Building and Loan (current and earlier years)	525.07	610.07	
Grant from Rockefeller Institute		600.00	
Interest on current funds (current and accrued)		415.80	
Interest on Lyman Fund (current and accrued)		166.23	
Allowance on reprints		591.04	
From authors for excess illustrations		158.25	
Payment for article published in July issue		92.91	
Payment for reprints		26.72	
Drafts and checks redeposited		16.50	
Payment for Smith Memoir		0.50	
Total receipts			11609.31
			$17512.64

Expenditures:

Printing, distributing and storing PHYTOPATHOLOGY:			
Vol. XXXI, No. 11	$688.58*		
No. 12 and Index	851.52		
Vol. XXXII, No. 1	864.20		
No. 2	671.44		
No. 3	637.04		
No. 4	776.01		
No. 5	703.59		
No. 6	843.59		
No. 7	799.84		
No. 8	703.75		
No. 9	761.02		
No. 10	681.04	$8981.62	

Postage, PHYTOPATHOLOGY	370.84	$9352.46	
Secretarial work and office expenses, Editor in Chief		330.87	
Secretarial work for Business Manager		310.00	
Secretarial work for Advertising Manager		44.25	
Stamps and stamped envelopes		42.96	
Supplies		14.69	
Printing		38.63	
Postage on 30-Year Index (part)		8.18	
Transferred to other accounts:			
E. F. Smith Memoir	0.50		
Science Press, for reprints	26.72	27.22	
Refund, subscriptions		25.50	
Checks returned by bank		16.50	
Withdrawn from Building and Loan (current funds) for deposit in checking account		248.16	
Purchase of early numbers for resale		32.50	
Insurance on back volumes		10.04	
Telegrams		0.59	
Total expenditures			$10502.55
Balance on hand:			
Checking account		$2510.09	
Northwestern Fed. Savings and Loan Assoc.		4500.00	7010.09
			$17512.64

* Total cost, $791.13, less $102.55 paid for article by author.

The 30-Year Index. In September, 1941, an edition of 1000 copies was printed. Six hundred and fifty copies have been mailed in response to orders, while 14 copies are being held for future shipment to members and subscribers in occupied or enemy countries. This leaves available a stock of about 335 copies. A summary of receipts and expenses, included in financial reports elsewhere, follows:

Receipts:			
Sale of index, April, 1941–November, 1942 inclusive			$3043.78
Expenses:			
Honoraria to editor and collaborators		$ 762.50	
Printing and distribution		2084.50	
Other expenses		356.55	$3203.55

Accounts payable total $88.00. Against the deficit of $159.77 we have the 350 copies still stored at Science Press.

H. A. EDSON

Report of the Advertising Manager. There were 97 revenue-producing advertisements, occupying 61 pages and consisting of 34 full-page, 45 half-page, and 18 quarter-page insertions. During the year 1942, 14 commercial companies used our Journal as advertising medium.

There were 22 nonrevenue-producing advertisements, occupying 12½ pages and made up of notices regarding Phytopathological Classics, the Society Clearing Agency, the 30-Year Index, and a few others.

Contracts in 1942 totaled $973.96.

Kenneth J. Kadow was appointed Advertising Manager at the annual meeting held in Dallas in 1941, and carried on the work through November, 1942, when he resigned to take a position in South America. At the request of the Business Manager, I have since managed the advertising for PHYTOPATHOLOGY.

S. L. HOPPERSTEAD,
Advertising Manager

Report of the Editor in Chief. Volume 32 of PHYTOPATHOLOGY contains, exclusive of the index, 1100 pages of printed matter and illustrations classified as follows: 120 articles, 46 notes, 4 reports of meetings, 8 book reviews, 137 abstracts, 233 text figures, and 1 frontispiece.

From December 11, 1941, to December 10, 1942, a total of 171 manuscripts of articles, notes, book reviews, and reports of Society meetings were submitted for publication in PHYTOPATHOLOGY. Nine manuscripts were either recalled by their authors or returned to them as unsuitable for publication in our Journal. There are now in press 49 articles and 92 abstracts. Other manuscripts now on hand (Dec. 10) comprise a total of 546 typewritten pages. It is estimated that enough manuscripts have been accepted and are now on file to fill about 720 pages of PHYTOPATHOLOGY.

At this time last year this figure stood at 770, a difference of 50 in favor of 1942. In December 1940 those accepted and awaiting publication were sufficient to fill 820 pages.

Repeated emphasis on the necessity of brevity and conciseness of statement in manuscripts, greater care in the preparation of tabular matter, a more careful choice of and improvement in photographic and other illustrative material, and increased attention to accuracy in preparing citations to literature has borne appreciable fruit. These marked improvements have lessened considerably the amount of editorial work necessary to the preparation of manuscripts for the printer.

The editor takes this opportunity to express his gratitude to members of the Editorial Board and others who from time to time have been called upon for assistance in appraising, constructively criticising, and otherwise improving certain manuscripts that seemed to call for such attention before we could finally decide on what disposition to make of them.

HARRY B. HUMPHREY

Report of the Manager of Phytopathological Classics for the year 1942. I beg to submit herewith the annual report of my stewardship as manager of Phytopathological Classics:

Report for the fiscal year beginning December 1, 1941 and ending December 1, 1942

Classics No. 1:	On hand 12–1–41	65	
	Sold during year	31	
	On hand 12–1–42		34
Classics No. 2:	On hand 12–1–41	267	
	Sold during year	33	
	On hand 12–1–42		234
Classics No. 3:	On hand 12–1–41	362	
	Sold during year	36	
	On hand 12–1–42		326
Classics No. 4:	On hand 12–1–41	425	
	Sold during year	38	
	On hand 12–1–41		387
Classics No. 5:	On hand 12–1–41	672	
	Sold during year	46	
	On hand 12–1–42		626
Classics No. 6:	On hand 12–1–41	793	
	Sold during year	81	
	On hand 12–1–42		712
Classics No. 7:	On hand 12–1–41	0	
	On hand 3–1–42	1000	
	Sold during year	221	
	Gratis copies	17	
	On hand 12–1–42		762

Receipts:

Cash balance on hand 12–1–41	$345.14	
Receipts during year	353.10	
Total		$698.24

Expenditures:

Postage	$ 14.00	
Express	1.00	
Bank charges	.85	
General Printing	21.00	
Classics #7	298.17	
Proof reading	4.50	
Total expenditures		$339.52
Balance on hand December 1, 1942		$358.72
Due on accounts 12–1–42		$ 13.00

Report of the Necrology Committee. In 1942 there were three deaths within our membership as follows:

JOSEPH CHARLES ARTHUR, April 30;
M. MITRA, July 10;
ARTHUR LEWIS PIERSTORFF, July 29.

A. G. JOHNSON
M. B. WAITE

Report of the American Phytopathological Society Committee on Biological Abstracts and the Union of American Biological Societies. During America's first year in the war BIOLOGICAL ABSTRACTS has made a magnificent showing in spite of the progressively increasing difficulties stemming from the world catastrophe and involving such vital matters as war censorship; reductions in the number of scientific periodicals, books, and reports from some parts of the world; falling off in subscriptions from the war-torn countries; and excessive turnovers in abstracters, section editors, and supplementary indexers. It is due only to the hard work and able leadership of Drs. Flynn and MacCreight as editors and Mr. Anderson as business manager, together with the full cooperation of a devoted staff and the backing of a sympathetic board of trustees, that so much has been done by so few.

As to subscriptions, a net gain over last year of some 46 to the complete and 86 to the original five sectional editions is reported for the United States. This indicates that Biological Abstracts is filling a real need here and testifies to the firmness of its endorsement by American biologists: this support is, indeed, very good but still not good enough when balanced against the rising costs of publication. Nevertheless, 1942 saw 23,437 abstracts published on 2,377 pages of the ten regular abstract issues of volume 16, a notable achievement in view of the problem of procuring abstracts, particularly of the European literature, under present world conditions. In fact, the continued emphasis and effort towards a fuller abstracting of the biological literature of the world has led to a coverage of about 1700 periodicals in 1942 as compared with 1550 for the preceding year, and greater progress along these lines is hoped for in 1943.

Other advances have included the establishment of a sixth section of Biological Abstracts, Section F—Abstracts of Animal Production and Veterinary Science, which began with January 1942. This new section is not only firmly established but yielded a small profit during the year of its birth. Furthermore, in response to what appeared to be an active demand from many directions, the organization has undertaken during 1942 the promulgation and preparation of a seventh sectional edition, Section G—Abstracts of Food and Nutrition Research, publication of which begins with the issue of January 1943. These two sectional editions are simply rearrangements and reprintings of abstracts also appearing in the complete as well as the original five sectional editions. In this way many biologists who were formerly untouched because there was no one section serving their interests have now been led to subscribe.

During the course of the years Biological Abstracts has come to have the cooperation and collaboration of a very large majority of the active biologists of the United States and many thousands in other countries. The author-abstracting plan is in successful operation for about 250 English language periodicals and has had the supplementary advantage of leading many biologists to volunteer abstracts of their own papers published elsewhere. Special collaborators (listed in the January 1943 issue), each assigned the abstracting of one or more periodicals, now number about 1,100 while over 2,000 others are available for special assignments. There are 150 section editors. Subscriptions total about 3,000. Biological Abstracts has thus become not merely an abstracting journal, but a vast cooperative bibliographic and scientific undertaking, which is steadily developing into an instrument of greater scope and utility.

As to the financial outlook, the picture is less bright but far from black. Although contributions from industrial concerns in 1942 amounted to $3,150 as compared with $700 in 1941, the year ended with a deficit of about $6,000 which must be withdrawn from the very limited reserve funds. There is no assurance that this industrial support will continue. In order to deliver the type of service needed, at least $57,000 in total support for the year should be forthcoming. In view of current trends only about $37,000 can be counted upon from subscriptions. Since this, even with an added $5,000 for the sale of advertising space, still falls short of the lowest estimated needs by $15,000 it is obvious that if standards and coverage are to be maintained, further substantial support from the biological societies, from interested industrial concerns, and from individual biologists generally is an essential desideratum.

Subscriptions to Section D—Plant Sciences (which includes phytopathology and 10 other subject divisions) numbered 335 in the United States during 1942, representing an increase of 23 over the preceding year. Even with the falling off in foreign subscriptions the Section has somewhat better than held its own. This indicates that it is performing a genuine service to plant science and is deserving of still greater support.

For its most healthy advancement science looks well into what has gone before, and now, of all times in history, progress and more progress is the crying need. Here is the only instrument in current existence that serves the whole field of biological research. Biologists: You need Biological Abstracts and Biological Abstracts needs you!

FREDERICK V. RAND, Chairman

Dec. 31, 1942.

Report of the Society's Representative on the Division of Biology and Agriculture, National Research Council. It was the major aim of the Division in 1942 to do everything in its power to assist scientists in the fields of biology and agriculture to render maximum service to the war effort. Actions were taken in this direction at the annual meeting in Washington April 11, 1942, and conferences centering around wartime problems were held under Division auspices at various times during the year. This report presents only activities that seem of interest to The American Phytopathological Society.

At the annual meeting a proposal was made for a special committee to head up the wartime activities of the Division. In line with this, E. C. Stakman of this Society was asked to head a conference on Divisional war activities. This conference, attended by 19 biologists, met on August 2. E. C. Stakman and J. G. Horsfall represented the War Emergency Committee of the Society. At this conference the danger of spread by enemy agents of destructive plant and animal pests was brought out. The possibility of serious injury to agriculture also was foreseen from any wartime curtailment of funds for insect-pest and plant-disease surveys or for plant-quarantine enforcement. A real hazard was visualized in the possibility of our armed forces bringing back home dangerous parsites from various parts of the globe, particularly the Pacific area. The conference expressed itself in a motion urging the proper authorities to deal adequately with such wartime problems of protection against foreign insect pests and plant diseases. In view of the need of the Nation for the services of biological and agricultural scientists in the war effort, the establishment of a permanent central committee of the Division was recommended to act as a clearing house for wartime activities.

At the annual meeting of the Division a Crop Protection Committee was established. E. C. Stakman was appointed Chairman. With him J. G. Horsfall and J. G. Leach represent The American Phytopathological Society, and J. L. Horsfall, and W. P. Flint represent the American Association of Economic Entomologists, E. F. Phillips, ex-officio. This committee met on October 12 to consider activities of common interest to both professional groups. In its program the committee decided to work for

(1) the more adequate accumulation of precise information in regard to national and regional plant-disease and insect-pest occurrence and damage as a basis for more effective control programs;

(2) more adequate education of the general public in regard to the menace created by plant diseases and insect pests;

(3) more adequate summarization of important information on crop pests and diseases for the use of extension men and investigators;

(4) the promotion of closer cooperation between entomologists and plant pathologists on a regional and project basis;

(5) closer cooperation between the two profesisonal groups in breeding crop varieties for combined resistance to insect pests and plant diseases;

(6) needed programs for the suppression of important plant diseases and insects;

(7) the wartime continuance of basic research in those fields where interruption would result in disservice to the Nation;

(8) Arrangements for the best possible services with respect to fungicides and insecticides.

At the annual meeting publication was announced of papers read at symposia held by the Committees on Genetics of Pathogenic Organisms and Aerobiology, respectively. Of wide value, these papers include material of phytopathological interest.

The Committee on Maintenance of Pure Genetic Strains indicated that it felt itself under heavy responsibility because of difficulties created by war conditions which might make it hard to preserve all of the needed pure strains of breeding stock.

The discussions at the annual meeting disclosed a large interest in rendering aid to Latin-American Republics in the fields of biology and scientific agriculture.

A National Research Council Fellowship was awarded to B. R. Houston, California Experiment Station, Davis, member of the Society.

Robert F. Griggs, Chairman of the Division, has been actively cooperating with others in working for proper recognition of the functions of professional biological and agricultural scientists in the war effort. In a statement on this subject, issued by the Division, the protection of crops from diseases was listed among the essential contributions to the war effort which require servicing by technical men. Dr. Griggs also has initiated the discussion of ways and means for welding the biological scientists of the country into some sort of strong, coherent, and effective organization.

At the annual meeting H. T. Cook was suggested for membership on the Board of Governors of the Crop Protection Institute. After he was commissioned in the Navy, the Division suggested the name of S. E. A. McCallan in his place.

HOWARD P. BARSS

January, 1943.

Report of the Tropical Research Foundation. The Tropical Research Foundation is dissolved and the capital and properties of the Foundation will be disposed of.

R. D. RANDS

Report of the Committee on Donations and Legacies for the Year, 1942. This committee has been largely inactive during the year due to the fact that its chairman was unable to attend the Dallas meeting and receive instructions from the Council as to the goal of the committee. The chairman originally and early proposed raising funds for the Endowment Fund through the agency of war bonds and stamps, but funds did not seem to be available for underwriting the effort. Late in the fall a letter was prepared to go to our membership calling attention to the opportunity of supporting both the War Effort and the association through the agency of War Bonds and Stamps. Due to the cancelation of the December meeting in New York this appeal was not sent.

It is suggested to the incoming committee that a real drive be made as proposed in 1943, with the Council appropriating a sum sufficient to underwrite the cost of printing and maintenance, not to exceed $100.

Respectfully submitted,

RICHARD P. WHITE, Chairman

Report of the Extension Work and Relaticns Committee. During 1942 the committee prepared a program for the annual conference sponsored by this group. It was proposed to discuss "What Should Our Major Plant Disease Control Objectives be in 1943?" Due to the postponement of the winter meetings of the Society, the conference was cancelled.

The Extension Subcommittee of the War Emergency Committee of The American Phytopathological Society, selected from the Extension Work and Relations Committee, has used the latter in the furtherance of certain of its projects, i.e., the members were consulted with and contributed to a questionnaire sent to heads of departments of plant pathology throughout the United States. The resulting information will appear in the report of the War Committee.

R. J. HASKELL, G. W. KEITT, R. H. PORTER, OTTO REINKING,, R. C. ROSE,
D. R. SANDS, W. B. TISDALE, S. B. FENNE, O. D. BURKE, Chairman

Report of the Public Relations Committee for 1942. During the past year the activities of this committee have been guided by the findings of the Committee of 10, which originally reported (Phytopath. **30**: 368. 1940) proposed policies and functions. Each number of the Journal has been carefully worked over by one or more members of the Committee. News-worthy articles have been popularized and disseminated to news writers and certain local publishers with release dates corresponding approximately with the issue of that number.

There has not been evolved a method by which the effectiveness of the work of the Committee can be measured. The personnel of this Committee has been increased and changes are anticipated since it was not selected on a basis of individual interpretation ability. The pathologists who have the writing ability to bridge the gap between the investigator and the layman belong on this Committee; their aid is solicited. Direction, assignments, instruction, organization, complete and prompt responsibility, willing and enthusiastic cooperation, suggestions and constructive criticism dominate the internal activities of the Committee. Liberal and accurate interpretation of original research with full credit has been the principal guide. Certain indications point toward a more inclusive coverage of the United States by including among the disseminating agencies certain newspapers and magazines located in the different parts of the country. The National Association of Science Writers are almost without exception located in the East.

The Committee wishes to recognize the cooperation and sincerely thank the science writers, publishers, officers of the Society and others who have materially aided in accomplishing the work of the Committee during the year.

J. A. PINCKARD, LUTHER SHAW, J. H. JENSEN, C. E. YARWOOD,
J. J. CHRISTENSEN, F. P. MCWHORTER, O. C. BOYD, K. S. CHESTER, P. A. YOUNG,
A. G. NEWHALL, G. H. STARR, C. T. GREGORY, G. F. WEBER, Chairman

Report of Temporary Committee on Recognition of Merit. In accordance with the Society's request, the President appointed this committee as a "temporary committee to study the matter of some form of recognition for outstanding papers presented before our Society, and that the papers be considered for the A.A.A.S. prize."

After studying the two phases of this assignment, your committee is impressed with the difficulties of appraising and evaluating contributions, especially on short notice. It is our opinion that any procedure for making awards that requires hurried action would be ill-advised. For example, it does not seem practical, for several reasons, to evaluate abstracts prior to presentation for recognition during the meetings at which they are presented. It would seem much more feasible to give recognition to one or more papers each year by requesting the author to develop his subject further and make a more complete presentation in the form of an invitation paper the following year. This in itself would constitute a recognition of merit and would give time for deliberate judgment as to whether one of these papers might warrant consideration for the A.A.A.S. prize.

To initiate, develop, and carry out some such program it is recommended that a committee be formed that shall consist each year of the last five past presidents of the Society, the chairman being the earliest presidential incumbent in the group, for example, H. W. Anderson would serve as chairman in 1943.

It is further recommended that the framework within which such a committee is asked to function be broad enough to allow for changes in the procedure as the committee gains experience along these lines.

G. H. COONS, H. S. FAWCETT, J. G. LEACH, G. L. PELTIER,
H. S. REED, W. D. VALLEAU, E. B. LAMBERT, Chairman

Report of the Committee on Regulatory Work and Foreign Plant Diseases. In accordance with the proposal approved at the Dallas meeting in 1941, a questionnaire was prepared by your committee and submitted to a considerable group of members of the Society especially in touch with various phases of virus disease activities, calling attention to the quarantine aspect of the virus problem as presented by Mr. S. A. Rohwer at Dallas and requesting an expression of opinion on two points.

(1) Which of the courses listed below most nearly represents the attitude you think should be adopted in our national plant quanantine policy toward foreign virus diseases? (The categories are merely suggestive. Your views and comments in any form will be helpful.)
   - A. The exclusion of foreign virus diseases is regarded as impracticable and should not be attempted.
   - B. Efforts should be made to exclude some or a few virus diseases of definitely injurious type and the rest should be disregarded.
   - C. We should aim to protect our important crops against the introduction of foreign virus diseases.
   - D. The proper course is to exclude all foreign virus diseases, to the extent that this can be done without undue disturbance to healthy agricultural development.
   - E. We should endeavor to exclude all foreign virus diseases, by every means in our power, up to the limit of public tolerance.

(2) Keeping in mind the two types of quarantine action mentioned by Mr. S. A. Rohwer, can you propose any specific plant, plant group, or virus complex for which quarantine action involving either host exclusion or entry under observation, or both, would be justifiable?

This questionnaire was sent out April 28, 1942, to 94 members, from whom 19 replies were received. In the first question as to the most desirable national plant quarantine policy toward foreign virus diseases one failed to consider this point and three included two items in the answer. The general summation favors: A, 3; B, 4; C, 5; D, 5; and E, 3. It is thus evident that there was no unanimity of viewpoint on this question and even no obvious trend of opinion which might be helpful to the plant quarantine authorities.

Answers to the second portion of the inquiry were even less complete. Of the 19 replies 3 of the four who touched on it made tentative or exploratory suggestions rather than specific recommendations. Only one of the replies presented anything which could be construed as a recommendation for action, this relating to stone fruits. Others suggested for quarantine consideration were corn, cotton, wheat, truck crops from south of the equator, soy beans, and peanuts. While the net outcome of this inquiry was somewhat disappointing in its tangible results, there was no question of interest and sincerity in the replies, and of the desire of the writers to give the subject helpful consideration.

As an index to the varied trends of thought expressed in these replies, the following summary presents something of the several points of view brought out:

In 8 cases quarantine difficulties were foreseen in regard to symptomless hosts, unknown host range, and multiplicity of hosts, often with different symptoms; the necessity of more energetic study of foreign virus conditions was stressed by 6; two believed a clearing up of our knowledge of the domestic virus situation through plant disease survey activity is a valuable preliminary to attacking the foreign problem; the ineffectiveness of port inspection methods was touched on by 3; the value of domestic control and eradication measures was regarded as high by 3; two called attention to the importance

of excluding foreign insect vectors; two others dealt with the possible factor of virus strains; three saw merit in the proposal to hold certain imported plant materials under detention until their health could be assured; three suggested consideration of foreign certification as a useful if not always satisfactory procedure; in 5 replies comment was made on the national quarantine administration to the effect that present quarantine measures were ineffective for virus diseases, that plant disease activities were not given sufficient consideration, and that its policy should be dynamic rather than static.

Individual comments brought out the following additional viewpoints:

There seems to be no need for a special policy on virus diseases apart from other diseases; the world's virus diseases appear to be already fairly well distributed; the possible importance of a foreign virus disease here is unpredictable; breeding programs for resistance to virus diseases should be extended; delay in introduction of foreign viruses is valuable in giving time for the development of control measures; bringing in foreign viruses for experimental purposes is objectionable; some reliance should be placed on cooperation with foreign countries in the virus problem; it is suspected that strawberry and raspberry diseases have been introduced in plant importations.

A. A. BITANCOURT, A. B. BUCHHOLZ, S. J. P. CHILTON, F. L. DRAYTON, M. R. HARRIS, W. A. MCCUBBIN, Chairman

Report of the Committee for Coordination of Research in Cereal and Vegetable Seed Treatments. During the past year this committee has carried on coordinated seed treatment programs with the vegetable crops, cotton, and the small grains including flax. The nature and extent of these programs is reported by the chairmen of the respective subcommittees.

Vegetable Seed Treatments. In 1942, the subcommittee on coordination of research on vegetable seed treatments, conducted a series of uniform seed treatment tests with some 30 cooperators in the United States and Canada. Tests were made with peas (George L. McNew), spinach (Harold T. Cook and Richard P. Porter), tomato (L. D. Leach), Lima beans (J. C. Walker and W. W. Hare), Irish potatoes (C. N. Clayton), corn (C. M. Haenseler) and lettuce (C. M. Haenseler). The seed was treated by the leader for each crop (except tomatoes and potatoes) and distributed to interested cooperators, who conducted replicated tests, and reported results to the leader. Complete mimeographed reports of these tests have been or are being prepared by the various leaders and will be distributed to those interested.

There seems to be growing interest in the work on vegetable seed treatments. Thirty-nine cooperators have expressed enthusiasm for the committee's work, and have requested seed samples for trials in 1943. These 39 people have expressed an interest in 19 crops and have requested a total of 207 tests. It is intended that the program should be continued with emphasis upon three war-time objectives: (1) determination of minimum effective dosages for preferred treatments and at least one substitute, nonmetallic compound; (2) location of suitable substitutes among the organic fungicides; and (3) evaluation of secondary substitutes that can be used for emergency adjustments that may be necessary for the 1944 season.

It is anticipated that tests will be made with sweet corn, peas, Lima beans, soy beans, spinach, beets and tomatoes, and Irish potatoes and possibly peanuts.

GEORGE L. MCNEW, Chairman Subcommittee on Vegetables

Cotton Seed Treatments. Cooperative plantings to evaluate various treatments of cotton seed were conducted in 8 States in 1942 under the supervision of the Cotton Seedling Disease Committee of the Cotton Disease Council. The treatments included: (a) various kinds of seed; viz., fuzzy, two degrees of reginning, and acid-delinting and (b) sixteen different chemicals and combinations of these chemicals. A mimeographed summary is in preparation and will be distributed to those interested. A special study of the feasibility of reducing the recommended rates of application of Ceresan has been made by R. Weindling in order to determine the possibility of securing the maximal control of seedling diseases with our limited supply of mercury.

C. H. ARNDT, Chairman Subcommittee on Cotton

Seed Treatments of Small Grains and Flax. Cooperative trials with wheat, oats, barley, and flax were carried out at 13 stations located in nine Northern States and three Canadian Provinces. Yield tests were made using two seed lots of each of these crops and standard and reduced doses of New Improved Ceresan. Comparisons were made with check plots and in the case of wheat with copper carbonate treated plots. An emergence of seedling-blight control test, using the same seed lots as in the yield tests, was made in which six treatments were compared. In a third series of tests, eight treatments were compared as to their ability to control smuts of wheat, oats, and barley and barley stripe. A mimeographed report of this work is being prepared for distribution.

While reduced facilities at many experiment stations may necessitate the elimination of the yield test it seems desirable to continue the emergence and smut-control tests for extensive testing of new organic compounds and "substitute" fungicides.

M. B. MOORE, Chairman Subcommittee on Cereals

Other Activities. Efforts have been made looking toward the organization of seed treatment programs for forage and pasture crops, small grains and sorghum in the Southern States, and corn in the northern and central parts of the Corn Belt. J. Harvey McLaughlin has organized a group for the testing of corn seed treatments in the Southern States and has kindly agreed to associate his group with this committee.

M. B. MOORE, General Chairman

Report of the Committee on Nomenclature and Classification of Plant Viruses. In 1941 the Committee expressed approval of the designation of plant viruses by a system of Latin binomials similar to that used for scientific naming of plants. This year discussions have centered around the choice of a system of naming and around the various systems of classification that have been proposed. The Committee favors (Johnson opposed) the use of the Linnean binomial system of nomenclature for plant viruses. A tentative classification based principally on induced symptoms and means of transmission, and consisting of one family and five genera, has been accepted by a majority of the Committee. However, further consultation with other virus specialists is desired before details of the system are completed and prepared for presentation.

Further progress has been made on the compilation of synonyms and descriptions of the viruses affecting the different groups of crop plants. Tentative plans for the publication of these descriptions and lists of synonyms have been formulated.

EUBANKS CARSNER, F. O. HOLMES, JAMES JOHNSON, H. H. MCKINNEY, H. H. THORNBERRY, FREEMAN WEISS, C. W. BENNETT, Chairman

Report of the Committee on Standardization of Fungicidal Tests. In continuation of its policy (as outlined in previous reports) of developing standardized methods for testing fungicides in the laboratory and field, your Committee wishes to report that three methods are now in a state suitable for publication. These methods are:

1. Definitions of fungicide terms.
2. The slide-germination method of evaluating protectant fungicides.
3. Standard laboratory Bordeaux mixture.

All methods have been extensively revised since their first appearance as mimeographed "Tentative Methods." The first method or "definitions" in particular has been subject to considerable thought, modification, and revisions. It has been evolved from the constructive criticisms of at least 30 pathologists from 15 different laboratories. The second and third methods include the findings of the recent and extensive research on the subject. It is believed that the three methods will be of assistance as a guide or standard in the testing of fungicides. Accordingly, your Committee recommends that the procedures be published in PHYTOPATHOLOGY under their authorship as "Recommended Methods."

Two tentative methods are being revised for publication as recommended methods. They are:

4. Tentative standardized laboratory and greenhouse procedure for testing the relative fungicidal efficiency of chemical dusts in the control of certain cereal smuts.
5. Tentative recommendations on standard spray nomenclature. This will include Part I—Apples and Peaches, and Part II—Pears and Cherries.

In addition there are in preparation two new tentative methods as follows:

6. Tentative method for testing vegetable seed protectants.
7. Tentative method for testing orchard fungicides.

The Committee would appreciate suggestions regarding new procedures suitable for standardization, as well as criticisms relative to the revision of methods 4 and 5.

Mimeographed copies of the various "Recommended" or "Tentative Methods" may be obtained from the Committee Chairman, Boyce Thompson Institute, Yonkers, New York.

J. G. HORSFALL, K. J. KADOW, R. W. LEUKEL, J. W. ROBERTS, C. F. TAYLOR, J. D. WILSON, S. E. A. MCCALLAN, Chairman

Annual Report of American Phytopathological Society War Committee. The formation of the committee was authorized at the Dallas meetings of the Society. There was fairly general unanimity regarding the general scheme of organization, which is based on recognition of the fact that there are regional problems and some of general concern. It seemed wise therefore to organize regional groups, taking advantage insofar as possible of existing divisions of the society, such as the Pacific Coast Division, the Southern Division and the New England Division. A special committee of pathologists

in the Upper Mississippi Valley had already been established under the chairmanship of I. E. Melhus. This group was already functioning well and seemed to furnish a good pattern for other similar groups. Accordingly, regional groups were organized or recognized as follows: New England, Middle Atlantic, Southern, Upper Mississippi Valley, and Pacific Coast. The Canadian Society was recognized, of course, as a coordinate group. The chairman of the divisions or regional chairmen were recognized as representing those groups on the general committee.

All committees have functioned actively. Obviously, however, some of them are of such nature as to permit quicker action than others.

The committees on Quarantines and Plant Disease Survey have been active and have tried to promote action designed to protect the country against the possible introduction of foreign pathogens or exceptionally virulent races of pathogens.

The committee on Extension canvassed the situation with respect to extension facilities in the various states and has attempted to improve the situation where there are not enough extension pathologists.

The committee on Seed Certification has accumulated data regarding seed certification and has sponsored a plan for the requirement of seed treatment for certified seed.

The Fungicide committee has obtained information regarding the availability of fungicides, spray machinery, and other pertinent data with respect to the control of plant diseases by chemical means. In addition, members of the committee have done considerable research on possible substitute fungicides and on the minimum effective dose of well-known fungicides, and have disseminated the information in various ways.

The chairman of each committee made a monthly report, which was sent to all the committee members, including regional representatives, who in turn transmitted this information to so-called "key men" in each State in their region.

Some of the regional groups have functioned extraordinarily well. For example, the Upper Mississippi Valley group has held several meetings; has prepared summaries of plant disease situations; has made further provision for summarized information regarding the control of the most important diseases, with a view to uniformity in recommendations, insofar as possible; and has been generally active in bringing about greater coordination of effort, not only in research, but also in the dissemination of information regarding control measures. The Middle Atlantic group has prepared a list of diseases and control measures for that area which has been mimeographed for general distribution within the area. The Southern group has issued several mimeographed circulars on the control of important diseases.

In general, these regional groups have been very effective in improving the situation with respect to disease control. Although their work has not been spectacular, they have succeeded in bringing about cooperation and coordinated effort within the region. The activities of these groups are fundamental to the effectiveness of the entire organization, and it would be remiss not to commend them for the work that has been done.

On of the most critical situations has been that with respect to manpower. Possibly the situation has been alleviated somewhat through the recognition by the Manpower Commission of the essential nature of the work of "agricultural scientists." Because the importance of plant products now is recognized more than it was at the beginning of the war, it seems likely that the need of well-trained pathologists and the need of replacements will be more clearly recognized in future than it has been in the past; at least there are indications that this is true. The chairman of the committee has exerted considerable effort to bring about alleviation of the situation with respect to personnel in plant pathology. The situation could easily become more critical than it now is, however, and efforts will be continued to bring about official recognition of the need of present plant pathologists and of potential replacements. Because of the provisions of the Selective Service Law, progress along these lines is not so rapid as might be wished; nevertheless, some progress has been made, unfortunately, however, only after too many men already have been lost.

During the past year, relatively little emphasis has been placed on publicity. It seemed desirable to accomplish something first. The time has come, however, when general, regional, and local publicity is highly important. The American people and those in authority owe it to the nation to recognize the importance of maintaining plant public health; and we owe it to the nation to furnish the information.

In addition, it is of the utmost importance to diffuse as widely and as promptly as possible pertinent information regarding plant disease situations and methods of control. Steps have been taken to attain these ends.

The work of the committee during the past year is an indication of what can be accomplished, now that the organization has had experience and has attained some coherence. There is every reason to believe the committee can function much more effectively in the ensuing year than it has during the past year. Although there have been many discouragements, pathologists have a highly essential national service to render; and, despite any resistance or apathy that may be encountered, we must exert every effort of

which we are capable in attempting to attain objectives we know to be in the best interests of the country. And not the least of these is increased effort to promote preventive plant disease measures, not only for the present, but also to safeguard the future.

E. C. STAKMAN, Chairman

Report of the Auditing Committee, American Phytopathological Society, as of December 1, 1942. We have examined the books and find them correct, with entries completely supported by vouchers. We wish to congratulate the Business Manager and Mrs. Meier on the clear presentation they have given of the financial transactions.

R. D. RANDS
CARL HARTLEY

Resolutions of the Committee on Resolutions. RESOLVED that the Society express to the management and staff of the Deshler-Wallick Hotel and especially to Mr. Tom A. Sahrey and Miss Martha Obetz its sincere appreciation for the courtesy extended to our membership and for cooperation in providing the officers and committees with excellent accommodations for conducting business.

RESOLVED that the Society express its appreciation to C. C. Allison, Secretary, for his continued efficient service to the Society under unusual and trying conditions.

RESOLVED that this Society express its sincere appreciation of the work of the officers and committees in promoting the interests of the Society throughout the year, and especially to the War Committee for its efforts in promoting the agricultural interests of the country.

Respectfully submitted,

NEIL STEVENS
W. G. STOVER
ALBERT E. DIMOND, Chairman

Elections. A special committee was appointed by President L. M. Hutchins to canvass the ballots. The ballots were opened and canvassed on December 26 by this committee, the report of which is given on page 84 of the January issue of PHYTOPATHOLOGY.

Sixty-six applications for membership to The American Phytopathological Society were received from January 1, 1942 to February 12, 1943. The Council elected all applicants as members of the Society.

Reports of Officers, Representatives and Committees. The reports for the year 1942, as presented on the previous pages, were read and accepted by the Council.

Appointments and Business Actions. The Council accepted the resignation of H. B. Humphrey as Editor-in-Chief of PHYTOPATHOLOGY, whose term was to expire December 31, 1943. The Council reappointed H. B. Humphrey as Editor-in-Chief of Phytopathology for a period of three years beginning January 1, 1943. J. M. Hamilton, R. E. Smith, W. W. Wagener, and G. C. Kent were appointed associate editors of PHYTOPATHOLOGY for a term of three years.

S. J. Hopperstead's appointment as advertising manager for PHYTOPATHOLOGY for 1943 was approved, and he was appointed as advertising manager for 1943.

Mrs. Agnes E. Meier was reappointed as assistant business manager of PHYTOPATHOLOGY for 1943.

L. M. Hutchins was appointed as representative to the A.A.A.S. Council for 1943 and 1944.

L. M. Massey for the period 1943 through 1947, and Donald Folsom for the period 1943 through 1948 were appointed as representatives to the Union of American Biological Societies (and Biological Abstracts).

The Council suspended appointment of a representative to the International Union of Biological Sciences.

J. C. Walker was appointed representative of the Society to the Division of Biology and Agriculture, National Research Council for a period of three years beginning July 1, 1943.

J. H. McLaughlin and K. W. Kreitlow were appointed to the special committee on Coordination in Cereal and Vegetable Seed Treatment Research.

J. A. Stevenson was appointed chairman of the special committee on Fungus Nomenclature.

The special committee on Seed Certification was discontinued, since the work of this committee is being taken care of during the emergency by a sub-committee of the War Committee.

The Council approved the appointment of K. Starr Chester, J. J. Christensen, Luther Shaw, and C. E. Yarwood to the standing committee on Public Relations named by

Pres. L. M. Hutchins in 1942. C. T. Gregory and L. M. Blank were appointed to the Public Relations Committee.

The matter of reprinting Classic #1 was left to the judgment of H. H. Whetzel, Manager of Phytopathological Classics.

W. E. Bodine was appointed to the special committee on Nomenclature and Classification of Plant Viruses. H. H. McKinney was appointed chairman of this committee.

The Council approved the report of the temporary committee on Recognition of Merit, and made this a standing committee with the understanding that the membership should rotate and should consist of the five past presidents of the Society, including the most recent ex-president.

H. W. Thurston was appointed to the special committee on Standardization of Fungicidal Tests. The Council recommended that the three procedures developed by the committee on Standardization of Fungicidal Tests be published in PHYTOPATHOLOGY as "recommended methods."

"By action of the Council the policy is established that all articles or abstracts accepted for publication in PHYTOPATHOLOGY, or official reports of committees of the Society, containing 'trade' or 'code' names of pesticides, must divulge in the text or footnotes the chemical composition of said materials."

The Council received a petition for the formation of a Potomac Division of The American Phytopathological Society and voted to submit it without comment to the membership for approval.

The Council acted to change the name of the War Emergency Committee to the War Committee of The American Phytopathological Society.

The Council approved a resolution by F. V. Rand, Chairman of the committee on Union of Biological Sciences and Biological Abstracts urging the Society members in so far as possible to enter and/or keep up their individual subscriptions at least to the Plant Science Section of Biological Abstracts, and to use their influence toward furthering departmental and institutional subscriptions.

The Council approved publication of a membership list of The American Phytopathological Society as a supplement to PHYTOPATHOLOGY as soon as possible.

The decision regarding holding a summer meeting of The American Phytopathological Society was left to the program committee and the executive committee of the War Committee.

The Council recommended that the regular winter meeting be held in conjunction with A.A.A.S., if they meet in Cleveland, Ohio, in 1943, subject to cancellation, if warranted.

The Council advised the Secretary to authorize the use of the membership list to the Agricultural Insecticide and Fungicide Association with the stipulation that the list would be used only for sending AIF News, and would NOT be available to firms comprising the Agricultural Insecticide and Fungicide Association.

JOSEPH CHARLES ARTHUR

January 11, 1850–April 30, 1942

Joseph Charles Arthur was graduated from the Iowa State College in 1872 with the degree of Bachelor of Science, and received the degree of Master of Science from the same institution in 1877. He was granted the degree of Doctor of Science by Cornell University in 1886. His honorary degrees included the Doctor of Laws, University of Iowa, 1916; Doctor of Science, Iowa State College, 1920, and Purdue University, 1931. He also pursued graduate study at Johns Hopkins and Harvard in 1879 and at Bonn in 1896.

In 1884, he was appointed botanist at the Agricultural Experiment Station, Geneva, New York. This was the first appointment to such a position in this country. In 1887 he was called to Purdue University as Professor of Botany. The following year his title was changed to Professor of Vegetable Physiology and Pathology and Botanist to the Indiana Agricultural Experiment Station. This position he held until his formal retirement in 1915. From then until his death he was Emeritus Professor of Botany. In the years between his graduation and his going to Geneva it was his determination to make botany his life work, but botanical positions were few. For a while he had no work: he taught country schools during several winters; he returned to the college at Ames several times to carry on special work; and was instructor at the Universities of Wisconsin and Minnesota during part of the time.

Dr. Arthur was a charter member of the American Phytopathological Society, and was a member of numerous other American and foreign scientific societies.

Although an important and pioneer contributor to several botanical fields, particularly physiology and pathology, his great life work was with the Uredinales. He was an inspiring leader in the investigation of the rusts for more than fifty years. From the time of his first rust papers in 1883 to his last papers in 1936, he was studying the life-cycles, relationships, classification and distribution of these fungi. The results are recorded in 150 papers and three major publications. He was much interested in the rules of nomenclature and made numerous trips to Europe to confer with fellow workers and to attend International Congresses. Throughout an unusually long life Dr. Arthur was productive not only through his own unceasing efforts but also through influence on the lives of students, assistants, correspondents and associates.

MANORANJAN MITRA

June 19, 1895–July 10, 1942

Manoranjan Mitra was graduated from Punjab University (Government College), Lahore, India, in 1916 with the degree of Bachelor of Science, and in 1918 he received the degree Master of Science from the same institution. He was granted the Diploma of the Imperial College of Science (London) in 1929 and the degrees of Doctor of Philosophy (1929) and Doctor of Science (1936) from London University.

For a time, Dr. Mitra was a Lecturer in St. John's College (Agra, India), but as his interests lay in research he went to the Imperial Agricultural Research Institute at New Delhi, India, first in 1919 as a graduate student and later as an associate. Soon after completing his training at London University, Dr. Mitra was appointed Assistant Mycologist at the Imperial Agricultural Research Institute (New Delhi, India), which position he held until the time of his death.

Dr. Mitra was a man of retiring yet friendly nature. He was especially studious and gained an extensive knowledge of plant diseases in India. He was a scholarly teacher and a most congenial associate and loyal friend.

ARTHUR LEWIS PIERSTORFF

November 12, 1895–July 28, 1942

Arthur Lewis Pierstorff was graduated from The Ohio State University in 1919 with a degree of Bachelor of Arts, and received the degree of Doctor of Philosophy from Cornell University in 1929.

Dr. Pierstorff was assistant county agent at Rochester and Fredonia, New York, 1921–1922; research fellow at Cornell University 1922–1923; plant disease director of the New York State spray service at Cornell University 1924–1926; extension horticulturist at Rutgers University, New Jersey State College of Agriculture 1926–1927; extension plant pathologist and professor of botany at The Ohio State University, 1928–1938; and professor of botany in the same institution from 1938 to the time of his death. He was a second lieutenant, field artillery, U. S. Army in 1918.

Dr. Pierstorff was a recognized authority in the field of plant pathology and pomology. He organized a centralized scab spray service for the State of Ohio, which has been an outstanding service to the orchardists of the State. The effects of his very capable and efficient service in extension work will long continue to be evident in all parts of the State. His affable, sincere, and genuine manner, and his warm personality won him many friends among his colleagues and among the agriculturalists of the State.